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ORIGINAL ARTICLES.

I.—The Fossil Phyllopoda of the Palæozoic Rocks.[1]

By Professor T. Rupert Jones, F.R.S. and Dr. Hy. Woodward, F.R.S.

(PLATE XIX.)

Contents.

I. *Phyllocarida*, from North Wales.
II. *Estheriæ*, from the Wetterau, Germany.
1. *Estheria striata* (Münster), var. *Muensteriana*, nov. figs. 1 and 2.
2. *E. Reinachii*, sp. nov., fig. 3
3. *E. Geinitzii*, sp. nov., fig. 4.
4. *E.* ——, var. *Grebeana*, nov., fig. 5.
III. *Estheriæ*, from Bohemia.
IV. *Phyllocarida*, from Iowa and Indiana.
V. *Anomalocaris*, from Canada.
VI. *Caryocaris Salteri*, from Australia.
VII. *Aptychopsis anatina* (Salter) and *Peltocaris Marrii*, sp. nov.
VIII. Geological Distribution of the Palæozoic Peltate Phyllopoda.

I. The *Phyllocarida*, from North Wales, referred to in the last Report (for 1892, p. 299) as having been lent by Mr. G. J. Williams, F.G.S., of Ffestiniog, have been duly examined, and several described and figured, together with some other specimens, in the Geological Magazine for May, 1893, pp. 198–203, Plate X., by T. R. Jones and H. Woodward. These comprise *Peltocaris Salteriana*, sp. nov. (Fig. 1), *Dipterocaris Etheridgei*, J. and W., 1884 (Fig. 3), *Aptychopsis Williamsii*, sp. nov. (Fig. 7), *Ceratiocaris insperata*, Salter, 1866 (Figs. 8 and 9); besides a fragment? (Fig. 6), an undetermined specimen (Cut, p. 203), a *Conularia* (Fig. 2), and two Mytiloid shells (Figs. 4 and 5).

The other specimens were: *Hymenocaris vermicauda*, Salter; four pieces from the Middle Lingula-flags at Borth, and (Middle?) in the cutting near Wern; and (not rare) from the Upper-Tremadoc beds at Garth Hill; all near Portmadoc. *Saccocaris major* (Salter); small individual from the Upper-Tremadoc at Tuhwnt i'r bwlch, Portmadoc. *Lingulocaris siliquiformis*, Jones; from the Upper-Tremadoc, at Garth Hill.

II. Several *Estheriæ*, from the Permian strata of Germany, submitted for examination by Baron Albert von Reinach, of Frankfort-on-the-Main, prove to be:—

1. Estheria striata (Münster), var. Muensteriana, nov. Pl. XIX. Figs. 1, 2.

Length, 3·66 mm.; hinge-line, 2·46 mm.; height, 2·0 mm.

Near to the var. *Beinertiana*, Jones (Monograph Fossil Estheriæ,

[1] Being the Tenth Report to the British Association, September, 1893.

Palæont. Soc. 1862, p. 25, pl. 1, figs. 11–14), but more angular and sloping posteriorly, and not nearly so truncate on that border as in var. *Binneyana*, Jones, *loc. cit.* fig. 9, nor rounded, as in var. *Tateana*, Jones, *loc. cit.* figs. 15 and 18.

Like the before-mentioned varietal forms of *Estheria striata*, this has a straighter back than shown in the figures given by Goldfuss and De Koninck, and a sharper postero-dorsal angle than seen in any of the published figures. We may mention that fig. 8, pl. 1, Monogr. Foss. Esther., is less oblong than the original figures referred to above, and is deeper (higher) posteriorly; fig. 9 is more truly oblong; figs. 11 and 13 are more oblique, sloping posteriorly; fig. 15 is oblique, but shorter than figs. 11 and 13; and fig. 18 is shorter and subquadrate.

The indications of interstitial ornament are feebly evident in some of those mentioned above, and we cannot find any in these now under examination.

Differing from the foregoing varieties it should be regarded, we think, as another variety, which we wish to specialize as *Estheria striata*, var. *Muensteriana*, thus naming it after Count Münster, who was one of the earliest observers of these Palæozoic Phyllopods and of other fossil bivalve Entomostraca.

In its postero-dorsal angle and long hinge-line this form much resembles the recent *Estheria Rubidgei*, Baird (Proceed. Zool. Soc. 1862, pl. 15, fig. 3).

Fig. 1 illustrates the two valves lying together on the matrix, and in Fig. 2 the left valve is seen without any perspective.

It is in bluish-grey Lebach Shale of the lower part of the Rothliegende (Permian), at Altenstadt in the Wetterau, Grand Duchy Hessen, where it was discovered by Herr von Reinach with other fossils, namely, *Xenacanthus Decheni*, Goldfuss; *Acanthodes*, sp.; *Branchiosaurus amblyostomus*, Credner (*Protriton petrolei*, Gaudry), and some of the leading plants of the Permian series.

In these Lower Lebach Shales from Altenstadt, Wetterau, A. von Reinach also found numerous small Ostracodes, which T. R. Jones and J. W. Kirkby have determined as:—

Leperditia Okeni (Münster), very common.
,, ,, var. *acuta*, J. and K. } less common.
,, ,, ,, *oblonga*, J. and K. }
,, ,, ,, *parallela*, J. and K., rare.
,, *Youngiana*, J. and K., rare.
Cythere superba? J. and K., common.
Bairdia? etc.

The series of formations yielding these Phyllopoda and Ostracoda have been especially studied of late years,[1] and belong to the Rothliegende of the Permian system of the Middle Rhine, Main, and Wetterau (equivalent to that of the Nahe and Saxony).

[1] See Ch. E. Weiss, *Fossile Flora der jüngsten Steinkohlenformation und des Rothliegenden im Saar-Rhein-Gebiete*, 1869–72, p. 6; Kayser's *Lehrbuch der geologischen Formationskunde*, 1891, p. 149; and A. von Reinach, '*Das Rothliegende in der Wetterau und sein Anschluss an das Saar-Nahegebiet*'; *Abhandl. Königl. Preuss. geol. Landesanstalt, neue Folge*, Heft 8, 1892, p. 3.

PART OF THE PERMIAN SYSTEM.

Upper Rothliegende { Kreuznach Beds. / Wadern Beds.

Lower Rothliegende { Upper / Middle / Lower } Lebach Beds. / { Upper / Lower } Cusel Beds. } or { Sötern Beds. / Tholey Beds. / Lebach Beds. / { Upper / Lower } Cusel Beds.

CARBONIFEROUS SYSTEM.

Upper, Middle, and Lower Ottweiler Beds.
Upper, Middle, and Lower Saarbrück Beds.

Estheriæ are also known in the Lower-Lebach Beds at Baerweiler-on-the-Nahe.

2. ESTHERIA REINACHII, sp. nov. Pl. XIX. Fig. 3.

Length, 3·2 mm.; hinge-line, 1·73 mm.; height, 1·86 mm.

This suboval *Estheria*, represented by two united valves (concave and one imperfect), is shorter and proportionally higher than Fig. 2, and has a much shorter hinge-line, which is straight, and not quite equal in length to the height of the valve. The umbo is not so near to the antero-dorsal angle as it is in Figs. 1 and 2, and therefore the ridges or lines of growth are less obliquely concentric with the umbo; they are also wider apart.

This form is not so bluntly rounded at the ends as *E. tenella* (Monogr. Foss. Esther. p. 31, pl. 1, fig. 26; pl. 2, fig. 39; and pl. 5, figs. 1–7); and it is much too angular and sloping posteriorly to match Goldenberg's pl. 2, fig. 9. In this last-mentioned feature it shows an alliance with *Estheria striata*; but its shape and proportions decidedly separate it as a species, and we give it the name *E. Reinachii*, after Albert von Reinach, who discovered it in the light-grey shale of the Upper-Lebach Beds in the Engelthal, near Altenstadt, in the Wetterau.

3. ESTHERIA GEINITZII, sp. nov. Pl. XIX. Fig. 4.

Length, 1·4 mm.; hinge-line, 1·0 mm.; height, 1·05 mm.

This (left valve) is subquadrate, with the anterior and ventral more fully rounded than the posterior border. The back is straight, and the umbo is at its front end.

This somewhat approaches to the shorter and deep (high) forms of *Estheria minuta* (Monogr. Foss. Esther. pl. 2, figs. 1, 5), but is readily distinguishable. It is still nearer in shape to a form of *E. Mangaliensis*, *op. cit.* pl. 2, figs. 20, 23, but the latter has not the postero-dorsal angle sufficiently pronounced. *E. subquadrata* (GEOL. MAG. 1890, Pl. XII. Fig. 2) has some resemblance to the form shown by Fig. 4, but it is not truncate anteriorily, and its postero-dorsal angle is weak.

The steep slope of the front edge, the full ventral curve, the contracted posterior moiety, and the well-pronounced postero-dorsal angle distinguish this form from any yet published. We dedicate

it to our old friend Hofrath Geinitz, of Dresden, who has always been deeply interested in fossil Entomostraca and in the strata from which those of the Wetterau have been obtained.

This short form, deep (high) in its anterior moiety, is abundant (gregarious) in a dark greenish-grey, nearly black, shale, ferruginous on one face, of the Lebach Beds, from the Boos Tunnel, on the Rhine-Nahe Railway, and on the same geological horizon as at Altenstadt.

4. Estheria Geinitzii, var. Grebeana, nov. Pl. XIX. Fig. 5.

Length, 1·2 mm.; hinge-line, 1·05 mm.; height, 0·9 mm.

Fig. 5 (right-valve) is subtriangular and differs from Fig. 4, owing to the great proportional length of the hinge-line and the less fully rounded free margins. The front border is truncate, sloping downwards and inwards; and the hinder margin slopes downwards at once and forwards, and not partly outwards as in Fig. 4.

These differences in outline do not seem to be due to bad preservation, for the ridges are truly concentric with the margins, as far as they are exposed; but they are varietal, if not sexual. Hence Fig. 5 may be distinguished as var. *Grebeana*, after Herr Grebe, of the Prussian Geological Service, who found it crowded together with *E. Geinitzii* in the hard, dark-coloured Lebach Shale from the railway tunnel near Boos, a village about one kilometre from Münster-on-the-Nahe.

III. In Katzer's Geologie von Böhmen, III. Abtheilung, 1892, the following fossil Phyllopoda are mentioned:—

P. 1169, *Estheria cyanea*, Fr., from Lubna ? (Lubno).
P. 1156 ,, *tenella* (Jordan), from Nürschan (Nýřany), } Post-
P. 1156 ,, sp. from Třemošnà, } Carboniferous.

Since that date our friend Dr. Anton Fritsch has shown us some figures of Phyllopods which probably comprise those referred to above. These figures are: 1, *Estheria*, from the lowest horizon of the Permian system of Bohemia, in the bituminous shale of Nyràn, near Pilsen; 2, *E. cyanea*, sp. nov., Fritsch, from the Middle Permian, in bituminous shale from Kaunovà; 3, an *Estheria* from Upper Permian bituminous shale at Kàstialov; 4, an *Estheria* from the limestone with *Palæoniscus Vratislavensis* of the Uppermost Permian at Braunau; 5, an *Estheria*, also from the Uppermost Permian Limestone. These, with some Ostracodes, will be published in due course by Dr. A. Fritsch in his "Fauna der Gaskohle," some parts of which have been already issued.

IV. S. S. Gorby, State-Geologist has issued some "Advance Sheets from the Eighteenth Report of the Geological Survey of Indiana" (8vo. Indianapolis, September, 1892), in which the Palæontology is done by S. A. Miller and S. A. Casseday (see p. 23). Some *Phyllocaridæ* of the family of *Pinacaridæ* are treated of, and at p. 77, pl. ix. fig. 37, the post-abdomen (trifid) of *Mesothyra Gurleyi*, n. sp., from the Kinderhook group, at Le Grand, Iowa, is described and

illustrated; and at p. 78, pl. ix. figs. 43–46, *Macrocaris Gorbyi*, n. gen. et sp. from the Keokuk group, at West Point, Indiana. Of this latter form, fig. 43 shows the interior of the carapace valves and four abdominal segments. Fig. 44 gives four and part of another abdominal segment, and the post-abdomen slightly broken at the end. Fig. 45 is eight abdominal segments and the post-abdomen. Fig. 46 is a tooth, found in the same rocks, that may possibly belong to the internal masticatory apparatus.

V. In the Canadian Record of Science, vol. v. No. 4, October, 1892, pp. 205–208, Mr. J. F. Whiteaves gives a "Description of a new Genus and Species of Phyllocarid Crustacea from the Middle Cambrian of Mount Stephen." The fossil is shown by a figure at page 206, and named *Anomalocaris Canadensis*, gen. et sp. nov. The diagram and description do not make it appear to us to be a Phyllocarid.

VI. Mr. Robert Etheridge, jun., in the Records of the Geological Survey of New South Wales, vol. iii. part 1, 1892, pp. 5–8, pl. iv. describes and figures four specimens of the *Hymenocaris Salteri*, M'Coy, and states his belief that they belong to *Lingulocaris*; and, as there is a *L. Salteriana*, he thinks that they should be called *L. Maccoyii*.

One or more specimens of this Australian species had been seen by Mr. J. W. Salter, and referred by him to *Caryocaris* with some doubt. We have adopted Mr. Salter's conclusion, both in a former Report (for 1883) and in the Monogr. Brit. Palæoz. Phyll., Pal. Soc. 1892, p. 93. Comparing Mr. Etheridge's figures with those of *Caryocaris* given by ourselves (*op. cit.* pl. xiv. figs. 11–15), we find that one of ours is as large as any of the former, and that the modified shape of the ends of the valves does not necessarily remove them from *Caryocaris*.

VII. With respect to *Aptychopsis cordiformis*, sp. nov., and *Peltocaris anatina*, Salter, mentioned at page 299 of the Report for 1892, Mr. J. E. Marr informs us that the words "Coll. Marr" should not have been attached to the former in our Monogr. Pal. Phyll. part 2, 1892, p. 103, pl. 15, fig. 2, for it was collected long ago, being the only Palæozoic shield-shaped Phyllopod in the Cambridge Museum when Salter labelled it *Peltocaris anatina*, overlooking its real generic character, and perhaps regarding it as a distorted specimen. By this name the specimen has been referred to in lists of fossils as from "Wenlock," and the real *Peltocaris*, which we have named *P. anatina* (Monogr. Pal. Phyll. p. 114, pl. 16. figs. 4–9) is a "Llandovery" fossil. It seems to be expedient to give the old name *anatina*, instead of *cordiformis*, to the *Aptychopsis* (p. 103), as intimated by Mr. Marr in the Geological Magazine for December, 1892, p. 535; and to distinguish the *Peltocaris* (p. 114), some specimens of which were collected by Mr. Marr, as *P. Marrii*.

VIII. We here append a table showing the geological distribution of the several Peltate Phyllopods described and figured in our Monograph and referred to at page 298 of the Report for 1892.

Aptychopsis prima, Barrande
,, ,, var. *longa*, J. and W. } Étage E e l, Bohemia.
,, ,, var. *secunda*, J. and W. }
,, *Barrandeana*, J. and W. Birkhill group (upper part of the Moffat series).
,, ,, var. *brevior*, J. and W. Birkhill group?
,, *anatina* (Salter). Lower Wenlock, Ulverston.
,, *lata*, J. and W. Gala series.
,, *glabra*, H. Woodward. Gala series.
,, *Wilsoni*, H. Woodward. Riccarton series.
,, *Lapworthi*, H. Woodward { Gala series. Birkhill group. Skelgill Shales, Lake district.
,, *ovata*, J. and W. Gala series.
,, *Salteri*, H. Woodward. Wenlock Shale, South Wales.
,, *subquadrata*, J. and W. Upper Silurian, Ireland.
,, *angulata*, Baily { Upper Silurian, Ireland. Brathay Flags (?), Lake district. Birkhill group?
,, *oblata*, J. and W. { Riccarton series. Gala series. Birkhill group.
Peltocaris aptychoides, Salter { Gala series. Birkhill group.
,, *Marrii*, J. and W. { Birkhill group. Skelgill Shales.
,, *patula*, J. and W. { Birkhill group. Skelgill Shales.
,, *Carruthersii*, J. and W. Birkhill group.
Pinnocaris Lapworthi, Eth. { Upper Silurian, Kendal. Lower Silurian, Girvan.
Discinocaris Browniana, H. Woodward { Birkhill group. Skelgill Shales.
,, *ovalis*, J. and W. Birkhill group.
,, *undulata*, J. and W. Birkhill group.
,, *gigas*, H. Woodward { Birkhill group. Skelgill Shales.
,, *Dusliana*, Novák. Étage E e l, Bohemia.

The general order of the strata is :—

4. Pentland or Riccarton Series. Brathay Flags. (Wenlock Beds.)
3. Gala Series.
2. Moffat Series. { 3. Birkhill group. Skelgill Shales. (Llandovery Beds.) 2. Hartfell group. 1. Glenkiln group.
1. Arenig Series.

EXPLANATION OF PLATE XIX.

PERMIAN ESTHERIÆ.

FIG. 1. *Estheria striata*, var. *Muensteriana*, nov. { From Lebach Shale, lower part of the Rotheliegende (Permian), at Altenstadt, in the Wetterau, Grand Duchy Hessen, discovered by Herr von Reinach.
,, 2. ,, ,, ,, ,,
,, 3. ,, *Reinachii*, sp. nov. Upper Lebach beds, Engelthal, near Altenstadt, Wetterau.
,, 4. ,, *Geinitzii*, sp. nov. Lebach beds, Boos Tunnel, Rhine-Nahe Railway.
,, 5. ,, ,, var. *Grebeana*, nov. Lebach beds, Boos Tunnel, near Münster-on-the-Nahe.

These specimens are preserved in the Geological Department of the British Museum (Natural History), Cromwell Road, S.W., having been presented, through the authors, by the Baron Albert von Reinach.

GEOLOGICAL MAGAZINE for May, 1893, page 202, line 14 from bottom, *for* Fig. 10 *read* Fig. 9.

II.—On the Conversion of Chlorite into Biotite in Rock-Metamorphism.

By Charles Callaway, D.Sc., M.A., F.G.S.

In a paper[1] read before the Geological Society of London, in 1889, I contended that the biotite of the gneisses and schists of Malvern had been produced out of hornblende through the intermediate form of chlorite. As this mineral change is of capital importance in explaining the origin of the Malvern schists, I made it one of the principal topics of the paper, and I trusted that the evidence I offered in support of it would be considered adequate. The further communication on the Malvern rocks, which I read on April 26th of the present year, assumed the adequacy of this proof. I found, however, that in certain quarters some scepticism on the point still existed, and it was suggested that I had overlooked some of the chemical difficulties which seemed to forbid the acceptance of my view. I therefore crave permission to reply to this objection in these pages; and I desire, at the same time, to point out that since the reading of my paper in 1889, the production of biotite from chlorite has been affirmed by several writers of admitted authority.

Professor Lossen, in the paper[2] on the crystalline schists communicated by him to the International Geological Congress, which met in London in 1888,[3] distinctly takes my view. He states that biotite is produced in "diabase" as the result of contact with granite and other eruptive masses, and he adds that this biotite is visibly formed at the expense of chlorite originating in "augite or primary hornblende."

M. Michel Lévy, on the same occasion, communicated a paper[4] on an allied subject. He is describing the metamorphism of détrital rocks. In the first stage, the cement of the fragments forming (say) a sandstone is converted into chlorite and sericite. In a more advanced stage, "sericite and the chlorite give place to interlaced laminæ of black mica."

A third writer, Prof. Salomon,[5] describes a case somewhat similar to the last, but the conditions are simpler. A phyllite is in contact with an eruptive mass of diorite, and the chief change produced in the phyllite is the conversion of chlorite into biotite.

This mineral transformation has also been described by Rüdermann.[6]

I have not given the precise details of the causes of change in each of these cases, because my object is merely to record confirmations of

[1] On the Production of Secondary Minerals at Shear-zones in the Crystalline Rocks of the Malvern Hills, Q.J.G.S., August, 1889, p. 475.

[2] Einige fragen zür Lösung des Problems der Krystallinischen Shiefer, nebst beiträgen zu deren beautwortung aus dem Paläozoicum; Compte Rendu, p. 180.

[3] This date is of course prior to 1889, but Prof. Lossen's paper was not known to me till after mine had been sent in.

[4] Sur l'Origine des Terrains Cristallins Primitifs; Compte Rendu, p. 58.

[5] Zeits. d. deutsch. geol. Ges. 1890, xlii. p. 450.

[6] Neues Jahrb. v. Beilage-Band (1887), p. 643.

a statement. If I am wrong in affirming that chlorite may be converted into biotite, it is very singular that several foreign observers of undoubted competence should have independently arrived at the same conclusion.

If this mineral transformation is an observed fact, it may seem unnecessary to discuss theoretical objections to it; yet, since competent observers have so recently called it in question on the ground of these objections, it would be inexpedient to pass them over. Is there any theoretical reason why, under the conditions existing in the Malvern rocks, biotite should not be generated at the expense of chlorite? I venture to think there is none, and this I will endeavour to show.

It is rarely possible to determine the species of chlorite in the Malvern rocks, as the mineral usually occurs in irregular patches and strings. It is identified by its habit, its colour, its pleochroism, and its very low interference tints. The biotite is easily recognised, and does not require to be described in this place. For our present purpose, it will be sufficient to compare the average composition of the two minerals. The following percentages cannot be very far from the truth.

	Chlorite.	Biotite.
Silica	33	40
Alumina	16	18
Iron peroxide and protoxide	5	16
Magnesia	34	18
Potash	—	8
Water	12	—
	100	100

In the change from chlorite to biotite, we have to account for a gain of silica, iron oxide, and potash; and for a loss of magnesia and water.

The liberation of *silica* is one of the most obvious features of the first stage of metamorphism, viz. decomposition. The crushed diorite, which is to become a mica-gneiss, is quite dirty with disseminated iron oxide, and is often freely veined with calcite. The elimination of lime and iron oxide would, of course, set free plenty of silica.

The last paragraph tells us where the *iron oxides* come from. That they are in part used up in the generation of biotite can almost be demonstrated under the microscope. In some slides, grains of opaque matter lie in the midst of blotches of chlorite, and round each of these grains is a halo of biotite, which can be identified by its brown colour, its strong pleochroism, and its high interference tints. In other slides, the chlorite is traversed by cracks filled in with opaque brown granular matter, and each of these cracks is fringed on each side by biotite. This opaque matter must be some form of iron oxide, it is not material which, and one seems driven to conclude that the pleochroic halos are causally connected with the union of the constituents of chlorite with the iron oxide.

It is evident that we cannot trace *potash* under the microscope. Some of this alkali is furnished by the decomposition of the felspar of the diorite. An analysis of the medium-black diorite (my No. 1), made by Mr. Player, gives a percentage of 2·8 of potash. Another percentage by the same analyst is 3·9. In this case the diorite is the same variety as the first, but it has been slightly modified, and contains a little biotite. An analysis by Mr. Player of the coarse-grey diorite[1] (No. 3) yields 4·3 of potash; but this percentage is probably exceptionally high, as another of his analyses of the same rock, slightly crushed and decomposed, gives only 2·5 per cent. of potash. The schist formed out of this diorite contains 3·7 per cent. of this alkali, but in a schistose rock which is just graduating into this schist the percentage of potash is as low as 1·9. It appears then that at Malvern diorite itself supplies a certain amount of potash for the construction of biotite.

Another source of potash is the adjacent granite.[2] The effect of the infiltration of potash is seen in the production of biotite in diorite in the proximity of the veins. Analyses were made by Mr. Player of rocks in the section[3] at the southern end of Swinyard's Hill. At a few yards from the veined complex the diorite (No. 1) contains only 2·8 per cent. of potash. In contact with the complex of veins, the diorite is changed into biotite-gneiss, where the proportion of potash has risen to 5·3 per cent. There seems then to be little difficulty in accounting for the potash necessary for the conversion of chlorite into biotite.

We have next to consider the loss of magnesia and water. The reduction of the percentage of *magnesia* in the transformation of diorite into sericite-gneiss or into biotite-gneiss is demonstrated by analysis. Four analyses (Mr. Player's) illustrate the change from diorite to sericite-gneiss. The magnesia percentages are respectively 5·0, 5·3, 4·1, 2·6. The first (5·0) is from the uncrushed diorite; the second (5·3) is from the diorite crushed and decomposed; the third (4·1) is the rock crushed into a micaceo-chloritic grit; the fourth (2·6) is the sericite-gneiss. Two analyses of the same schist made at Owens College under the direction of Dr. Cohen give respectively 1·29 and 0·35 of magnesia. Analyses made by Mr. Player of rocks from the Swinyard's Hill section illustrate the change into biotite-gneiss. They give 7·3 of magnesia in the ordinary diorite, and 1·9 in the resulting biotite-gneiss. Another specimen of the latter yields to an analysis by Mr. Waller 2·8 of magnesia, and this rock passes into varieties in which two analyses give respectively 1·9 and 1·4 of magnesia. The elimination of magnesia is therefore clearly shown.

Water was not separately estimated in the analyses made for me. Its elimination would seem, however, to offer no serious difficulty.

[1] This rock contains too much potash for a normal diorite. As a large proportion of the felspar is plagioclase, and the silica percentage is only 47, it can hardly be a syenite.

[2] Discussed in Quart. Journ. Geol. Soc. (1889), pp. 482–487, 499.

[3] *Ibid.* p. 482.

Chlorite loses water even at a red heat, a clear proof that the affinity between the water and the other constituents of the mineral is not very strong. The temperature of metamorphism in the Malvern rocks often rose to the point of fusion in the shear-zones, and, if in other respects the environment of the chlorite were such as tended to change it into biotite, there would seem to be no theoretical objection to the expulsion of the combined water.

The decomposition of biotite (or hornblende) into chlorite is of course a very familiar fact, and, if the two minerals are found in the same rock with an apparent passage between them, it is natural that those who have not studied the evidence furnished by the Malvern rocks should adopt an old and well known explanation of the phenomena in preference to a new and seemingly improbable one. It seems easier to believe in a decomposition than in a reconstruction. We must, however, follow whither the facts lead us. The reason why in the Malvern rocks we have sometimes a decomposition of hornblende into chlorite, and sometimes a change of chlorite into biotite, is found in the difference of environment. Where the rock is slightly crushed, and there are no signs of rock-fusion, there is decomposition of hornblende; but where there is intense crushing and shearing, accompanied by a high temperature, reconstruction sets in and biotite is generated.

In the three papers which I have submitted to the Geological Society on Rock-metamorphism at Malvern, I have embodied the results of several years of careful work. If any parts of my argument are weak or mistaken, I respectfully ask that the defects may be pointed out.

III. — Notes on the Eocene Tertiary Insects of the Isle of Wight.

By the Rev. P. B. Brodie, M.A., F.G.S.

THERE are some points of special interest with reference to the Insect remains from the Bembridge Limestone, near Cowes, which seem to be worth recording. My friend Mr. Scudder, who has done so much to promote the study and elucidate the history of fossil insects, and who is our highest authority upon the subject, remarks in one of his papers in the United States Bulletin, that in no case had he observed the interior of any insect in a fossil state, and that the internal structure could hardly be expected to be detected. As a rule, no doubt, this is perfectly correct, and I have never noticed any insect relic either in the Purbecks or Lias which showed any portion of the interior, and I am not aware that any foreign fossils of a similar class where they occur have done so. But the Articulata of the Isle of Wight Tertiaries are certainly a remarkable exception. I have lately carefully examined a large number of specimens in my collection with a powerful lens, and in the majority of cases the insects, mostly of small size, have the interior of their bodies exposed, among which, as in other Tertiary deposits, ants, which chiefly belong to the Formicidæ, predominate;

but only one example of an Hymenopterous insect, an ant, is known earlier—from the Swiss Lias recorded by Heer. The insects in the Bembridge Limestone, as a rule, are lying on their backs, the interior of the body being exposed, and showing even the internal structure, in other words, the anatomy of the animal, and in one instance, even what appears to be the ovipositor, and in another the intestine, may be detected. It often happens that only a mould of the interior of the entire body of an insect is left, the soft parts having been entirely decomposed. The matrix is a more or less hard and somewhat peculiar limestone, with a very perverse and uneven fracture, and may have been deposited in a small lake under unusual conditions. The limestone is not laid down in regular laminæ, as in many other Tertiary, and not unfrequently in earlier formations, which in some respects is a better condition for the display of the *Insecta;* but at Gurnet Bay they lie often crowded together, and in all directions in the matrix, which is often angular and irregular in structure. Hence the remains are most difficult to work out and expose, though the minute parts are wonderfully preserved. Mr. A'Court Smith informs me that he has found several butterflies, generally ill-preserved, though I have one fine example retaining both wings and showing traces of colouring; but the body is much decomposed. I have also a Gryllus, apparently with attached wings, and a small Blatta. There are also numerous spiders, caterpillars, centipedes, and worms.

In some respects the Bembridge Limestone is, lithologically, not unlike the Rhætic at Aust Cliff, containing some well preserved insects, though only at one particular spot. Most of these Tertiary Arthropods must have undergone a considerable amount of decomposition and have been embedded with the lower portion of the body upwards, the very reverse of the ordinary preservation of most fossils of this class elsewhere. They appear to be confined to a very limited area, and so far are of local occurrence, for Mr. Starkie Gardner has stated that though he had carefully searched the equivalent beds in other parts of the island he had never met with them. This differs from the widespread range of Tertiary deposits in other parts of the world where, as in Colorado especially, there are several thin layers of fine-grained limestone which may be traced for many miles, more or less crowded with insect-remains in good preservation. The majority of these *reliquiæ* in the Isle of Wight are generally broken, crushed, and distorted, and the wings are not often attached; very different to those from Aix and other foreign Tertiaries. But the legs, antennæ, and eyes, are not unfrequently preserved, and in some cases the beautiful iridescent colouring of the body and wings are occasionally retained. This is rarely so in more ancient deposits, though the wings of *Brodiea* in the Coal-measures near Dudley retain their colouring and in other examples in the same deposits at Commentry, in France, and also in America.

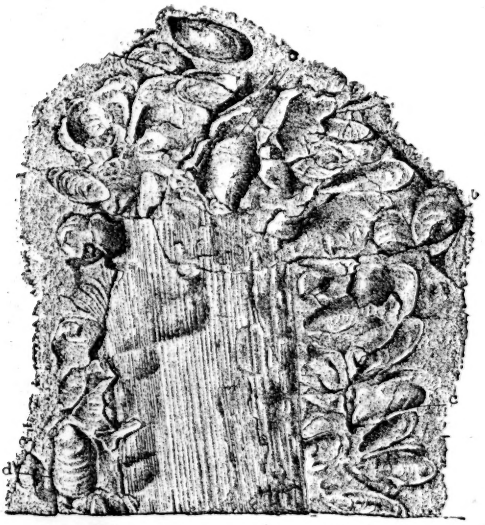
Insect remains have only been recognized of late years in the British Tertiaries (though long known abroad) in any considerable

number; and those only a few elytra of beetles; but now, through the intelligence and zeal of Mr. A'Court Smith in searching the rocks at Gurnet Bay, near Cowes, we owe the discovery of a large and varied series of Insects. My collection of Tertiary insects, numbering nearly two thousand specimens, is still unnamed and undescribed; and a few only of those in the British Museum, Natural History, are named and figured. It is much to be regretted that there is no English Entomologist who will undertake this work, and if Mr. Scudder was nearer, there is no one more competent to do this. Is there no one in this country who will take up the subject? No doubt those who have collections from the British Tertiaries, would willingly lend them for this purpose. I may add, that associated with these insects are several small feathers of birds, one of which is entire, the rest fragmentary. These are great rarities in British Tertiaries.

IV.—Description of a Slab from the shale above the Kinder Scout Grit, Rabchester, Lancashire. Obtained by R. H. Tiddeman, Esq., M.A., F.G.S.

By Wheelton Hind, M.D., B.Sc. (Lond.), F.G.S.

MENTION is made of this slab by Mr. R. Etheridge, jun., in his Presidential Address to the Royal Physical Society of Edinburgh, p. 50. The specimen is in the Museum of Natural History, Cromwell Road, South Kensington.



Piece of fossil wood, from the Shale above the Kinder Scout Grit, Lower Carboniferous, Rabchester, Lancashire, surrounded by closely-packed shells of *Anthracoptera*, which were doubtless attached to the wood by their byssi.

The slab shows a piece of fossil wood $2\frac{3}{4}$ in. long by about $1\frac{1}{2}$ in. broad, the exact nature of which is not determinable on account of

its bad state of preservation, but this is fortunately not germane to the subject; it lies flat and compressed and is surrounded on three sides by masses of Mollusca, in places two and three deep, which have doubtless been attached to the wood by their byssi. The anterior ends and in many cases the inferior borders are turned towards the piece of wood and are in close contact with it, while others are again attached to the first row, as in masses of living mussels.

The shells are much crushed; but in several places the distinctive characters of the genus *Anthracoptera* can be made out:—

(*a*) Is one showing the straight hinge-line, the triangular form, and oblique swelling.

(*b*) Is a specimen showing a typical posterior end.

(*c*) Shows a fairly well-preserved anterior end.

(*d*) Is a less crushed specimen than most.

Microscopically the shell-structure is identical with that of *Anthracoptera*.

This is the only specimen known which exhibits these shells attached by the byssus; but I have seen several slabs of small Posidonias similarly attached to calamite stems in the collection of Mr. George Wild, of Bardsley, from the Lower Coal-measures around Oldham.

V.—The Amount of Disseminated Silica in Chalk Considered in Relation to Flints.

By A. J. Jukes-Browne, B.A., F.G.S.

IT has been supposed, though I do not know who was the first to suggest it,[1] that the total amounts of silica existing in the Chalk with flints and the Chalk without flints respectively are very nearly equal: the idea being that if the quantity of silica disseminated through the flintless Chalk could be accurately estimated it would be found to be nearly or quite as great as the amount existing in the shape of flints in an equal thickness of flinty Chalk.

Proceeding on this assumption it seems also to have been inferred that silica was originally disseminated through the mass of the Upper Chalk, and that this silica has in some mysterious way been concentrated into nodules and layers of flint, leaving the surrounding Chalk in the condition of a nearly pure calcareous material. If this supposition were true it could doubtless be used as an argument in favour of the theory that flints have been formed by some process of "segregation" after the consolidation of the Chalk. I believe, however, that it is a pure assumption, made without any due examination of the facts, but, as it has never been disproved, I shall probably be doing a service to those interested in the knotty question of the formation of flints by arraying the evidence against it.

In the first place, I presume it will be granted that the silica which went to make the flints was a soluble form of silica such as that of Sponge spicules, Diatoms or Radiolaria. The insoluble silica which is present in the shape of quartz-sand and clay must therefore

[1] The late David Forbes, F.R.S., in Proc. Geol. Soc.—Edit. Geol. Mag.

be left out of consideration, and consequently no analysis of Chalk which does not separate the soluble from the insoluble silica will be of any use.

Here arises the question of what is "soluble silica?" In commercial analyses of soils and rocks the silica recorded as "soluble" is only the small amount which is soluble in warm hydrochloric acid; but, properly speaking, soluble silica is that which can be dissolved in an alkaline solution of a certain strength. Crystalline silica, such as quartz and chalcedony, are not soluble in such a solution, but all forms of non-crystalline or colloid silica are. We can therefore only use analyses which have been made by capable scientific chemists, and unfortunately there are not so many such analyses as geologists could desire.

The microscope, however, here comes to our assistance, for, by using the polariscope, we can easily see whether the siliceous particles are crystalline or colloid; checking the results by such good analyses as exist, we can determine whether flintless Chalk always contains soluble silica, and whether Chalk with flints contains little or none.

It will be convenient to consider the case of the Lower, Middle and Upper Chalk separately, for it is now known that flints occur in each of these divisions in more than one part of England.

1. *Lower Chalk.*—It used to be supposed that no flints were to be found in this division, but genuine flints, often with black centres, are common in the lowest part of the Chalk of Dorset; Mr. W. Hill, F.G.S., informs me that they also occur in that of Yorkshire. Siliceous concretions of the nature of flints also occur in the central part of the Lower Chalk of Wilts between Westbury and Urchfont.[1]

Mr. W. Hill has cut and examined samples of the Dorset Lower Chalk with flints, and finds that it differs from ordinary Chalk-marl, containing much less quartz and glauconite. There are few spicules, and no globular silica has yet been detected in any of the samples Mr. Hill has examined. The amount of quartz and glauconite is sometimes very small, and one sample of flint-bearing Lower Chalk was almost purely calcareous, with only one or two spicules visible in the slide. It might, therefore, be supposed that the Dorset flints occurred in Chalk which had been depleted of soluble silica.

The Wiltshire nodules, however, occur under just the opposite conditions, the surrounding Chalk being rich in colloid silica. Analyses by Mr. J. Brierly, of Southampton, gave over 12 per cent. of such silica, and the microscope shows that it exists partly in the form of sponge spicules, and partly in that of minute discoid and globular particles like those described by Dr. Hinde in the Malmstone of Surrey and Hants. Samples taken from just outside the cherty nodules showed no difference, except that the globules were rather larger than those in the mass of the deposit. The nodules themselves are simply portions of this siliceous Chalk saturated and cemented by an infiltration of chalcedonic silica.[2]

[1] Quart. Journ. Geol. Soc. vol. xlv. p. 405.
[2] Quart. Journ. Geol. Soc. vol. xlv. p. 415.

Are we to suppose that we have here a case of the arrested development of flint? Possibly, but it would be very rash to assume that the Dorset Lower Chalk was originally a siliceous Chalk similar to that of Wiltshire. Nor is the latter the most siliceous Chalk known, for some beds at Collingbourn Kingston, near Andover, in Hants, contain over 38 per cent. of such silica. The following analysis of Collingbourn Chalk I owe to the kindness of Professor J. B. Harrison, of Demerara, who adopts a special method for separating the free colloid silica from that existing in combination with bases such as Alumina and Iron.[1] The analysis is consequently of special value and accuracy:—

Analysis of Siliceous Chalk, Collingbourn.

Organic matter, etc.	1·69
Quartz	13·41
Colloid silica	38·69
Silicates (Clay, etc.)	14·75
Calcium sulphate	0·49
Calcium carbonate	30·77
Calcium phosphate	trace
	99·80

Here then is a Chalk which actually contains more colloid silica than carbonate of lime; if flints were formed by the subsequent solution and concentration of such silica, how is it that the Collingbourn Chalk is not now a pure Chalk with frequent bands of flints? Evidently the formation of flints is not a matter of simple subsequent concentration, neither does it depend simply upon the abundance of disseminated colloid silica.

2. *The Middle Chalk* is that which lies between the horizons known as the Melbourn Rock and the Chalk Rock. It is, so far as we know, a very pure Chalk. The few analyses that have been made show that it contains from 97 to 98 per cent. of carbonates, and that it is therefore as purely calcareous as many parts of the Upper Chalk.

The distribution of flints in the Middle Chalk is somewhat remarkable: they appear to be absent in the Isle of Wight and in North Dorset; they occur sparingly in the central zone in Wiltshire, and increase in abundance northward till in North Cambs and Suffolk they form frequent layers of nodules. The character of the Chalk composing the zone of *Terebratulina gracilis* varies, however, very little; it consists largely of single calcareous cells with a few Foraminifera embedded in a matrix of very finely-divided calcareous ooze. Sponge spicules are rare, and no globular silica has been observed. This description applies equally to the flintless Chalk of the south and west, and to the portion containing flints in the counties of Hertford and Cambridge. The following is an analysis of Middle Chalk with flints from 60 feet above the Melbourn Rock at Hitchin; it has been kindly made for me by Prof. Harrison with the express purpose of ascertaining the amount of colloid silica.

[1] Quart. Journ. Geol. Soc. vol. xlv. p. 414.

Analysis of Middle Chalk, Hitchin.

Organic matter	0·10
Quartz	0·15
Colloid silica	0·35
Silicates (Clay)	1·68
Calcium sulphate	0·29
Calcium carbonate	96·15
Magnesium carbonate	1·34
	100·06

This closely agrees with Mr. Hume's analysis of Chalk from the zone of *Terebratulina gracilis* (Isle of Wight), which contained 97·76 per cent. of carbonates, and he says "the main residue consisted of a light-brown clay, entirely free from siliceous particles."[1] He found a few Foraminifera, but no sponge spicules nor any indication in the shape of glauconite rods that spicules had ever been present. This Chalk has no flints, while that at Hitchin has a few.

3. *Upper Chalk.*—In this division, as developed in the South of England, the Micraster zones are characterized by the extreme abundance of flints, the Marsupite zone by their rarity or absence, and the zones of *Belemnitella quadrata* and *B. mucronata* by a moderate number.

The Chalk of all these zones is very pure and similar in minute structure, except that shell fragments are sometimes very numerous in the Micraster zones.

Mr. Hume's researches show that the carbonates usually amount to between 98 and 99 per cent., only two samples yielding less than 98. He found no sponge spicules nor any kind of colloid silica in any of the samples he examined, but glauconite rods, which seemed to be the casts of spicular canals, were numerous in the residue of the *coranguinum* Chalk. There are, however, beds in the zone of *M. cortestudinarium* in the South of England which are crowded with spicules in which the silica has been replaced by calcite.

Prof. J. B. Harrison has specially examined two samples of Upper Chalk for colloid silica and sends me the following results: (A) being from Chalk with many flints near base of *coranguinum* zone north of Salisbury, and (B) from the Marsupite zone, with few flints, Bishops Down, Salisbury.

Dried at 100° C.	A	B
Moisture	0·30	0·20
Quartz	0·32	0·50
Clay	1·18	0·45
Colloid silica	0·50	—
Carbonates by difference ...	97·70	98·85
	100·00	100·00

It will be noticed that while the Chalk with many flints (A), has an appreciable amount of colloid silica, that with few flints (B), has none at all. This is not the result that might be expected if the two Chalks had originally equal amounts of disseminated silica.

[1] Chemical and Mineralogical Researches on the Upper Cretaceous zones of the South of England, London, 1893, p. 51.

Mr. Hume's analyses also prove the Marsupite Chalk of Margate and of Studland Bay (Dorset) to be purer than the Chalk of the underlying *coranguinum* at the same localities. From four analyses from each zone given by Mr. Hume (*op. cit.* p. 74) it would appear that the amount of insoluble residue in the *coranguinum* zone averages 1·78 per cent., while that in the Marsupite zone only averages 1·02 per cent.

Conclusions.—The facts and analyses above given are, I think, sufficient to prove that there is no definite relation between the occurrence of flints and the absence or presence of soluble silica in the surrounding Chalk.

The great abundance of siliceous spicules in certain parts of the Lower Chalk and their rarity in the Upper Chalk, cannot be taken as evidence of the greater abundance of siliceous sponges in the former; as a matter of fact, remains of sponges other than free spicules are far more abundant in the Upper. Neither can the absence of disseminated spicules in the Upper Chalk be accounted for on the supposition that they were once there but have been removed in solution *after the consolidation of the Chalk*, for why should they remain in the Lower Chalk, which has been upraised, inclined and exposed to the same action of percolating water as the higher part of the formation? Moreover, if the spicules or other siliceous organisms had existed in the Upper Chalk and had been subsequently dissolved, we should find traces of them either as empty tubes or as calcite casts. As a matter of fact there are beds both in the Lower and in the Upper Chalk where spicules occur abundantly in the state of calcite casts, but flints do not occur in them, nor are they specially abundant below them.

Hence the conclusion I have arrived at, from consideration of all the facts known to me, is that Chalk which is now destitute of any remains of spicules has, since it became Chalk, always been destitute of such spicules. It is possible that spicules may have lain for a time in the ooze which became Chalk; but if so I believe they were eventually dissolved in the sea-water before that ooze was raised or compacted into anything like Chalk.

How then, it may be asked, has it come to pass that spicules in the Lower Chalk have so often been preserved? That is a question not easy to answer; I have been tempted to suppose that the depth of the water had much to do with it, for there is good reason to think that the Lower Chalk was formed at depths of from 300 to 500 fathoms; while the characters of the Upper Chalk certainly indicate a much greater depth of water. The material of the Upper Chalk was probably deposited much more slowly than that of the Lower Chalk, so that the spicules of decaying sponges might have been dissolved before embedment.

The formation of flints, however, has certainly nothing to do with depth of water, because they occur in all parts of the Chalk and in the chalky limestone of the Portland series; and yet there may be some connection between the solution of spicules, diatoms, etc., and the formation of flints. It has always seemed to me that one of the

conditions which led to the solution of spicules and the formation of flints was the presence of decaying organic matter; conversely it is not unlikely that the preservation of spicules is due to the absence of decaying organic matter at the time of their embedment.

It is known that some kinds of siliceous sponges periodically shed their spicules, and such shed spicules might be transported some distance by currents. The spicules in the Lower Chalk of Wilts seem to have been distributed in this manner, for remains of sponge-mesh are rare in that Chalk. We may assume, therefore, that when this Chalk was accumulated the amount of decaying protoplasm was very small, and consequently the spicules were not dissolved. In the Upper Chalk, on the other hand, and especially in the *Micraster* zones, there were evidently extensive sponge-fields, and yet spicules are seldom found except in the interior of flints which are silicified sponges. Does not this suggest the inference that the decay of the sponges set up reactions which caused first the solution of the scattered spicules and ultimately the precipitation of the silica in the form of flint?

VI.—Berthelot's Principle applied to Magmatic Concentration.[1]

By Alfred Harker, M.A., F.G.S.

IT is now a recognized fact that many igneous intrusions, especially of basic rocks, grow more basic in composition from the centre to the margin. This type, of what Vogt terms "magmatic concentration," has been discussed by several geologists, who agree in supposing that in such cases a magma, originally homogeneous, has become differentiated by the migration of the less soluble (more basic) ingredients to the cooler marginal region of the magma-reservoir.

Taking the same ground, I wish to say a few words as to the physical cause of such migration. The explanation which has been offered, and may be regarded as the current one, invokes what has been named "Soret's principle," and is based on the generally admitted analogy between an igneous rock-magma and an ordinary saline solution. Soret[2] found by experiment that when different parts of a solution, originally homogeneous, were maintained for several weeks at different temperatures, the salt in solution tended to accumulate in the cooler part of the liquid. Van t'Hoff,[3] in his memoir on "osmotic pressure," arrived theoretically at the same result, and showed that for equilibrium the concentration of the salt in different parts of the solution must be inversely proportioned to the absolute temperature. Those results of Soret which gave the highest degree of concentration agreed with this law, and it seems probable that in his other experiments sufficient time was not allowed for complete equilibrium to be effected.

The principle just noticed seems at first sight to lead to an

[1] A paper read before the Brit. Assoc., Section C, at the Nottingham meeting.
[2] Annales de Chimie (5), vol. xxii. pp. 293–297 (1881).
[3] Zeits. f. phys. Chemie, vol. i. (1887).

explanation of the concentration of iron-oxides, etc., in the cooler marginal part of an igneous rock-magma, but closer examination shows that the explanation is an inadequate one. To take a single instance: in a large intrusion of gabbro investigated by Mr. Marr and myself, the amount of magnetite was found to rise from less than one per cent. in the centre of the mass to 25 per cent. at the margin. It is clearly inconceivable that the absolute temperature at the centre was ever twenty-five times that of the margin. Other equally strong examples might be cited. Soret's principle is therefore insufficient, and it is not difficult to suggest a reason for its failure. The principle presupposes a dilute solution: if we imagine the solution to be near the point of saturation, and crystallization to take place in the parts actually saturated concurrently with the concentration, we have to deal with an essentially different set of conditions. We must then fall back on the general law of the degradation of energy, as formulated, for instance, in Berthelot's principle.[1] "Every chemical change accomplished without the intervention of any external energy tends to the production of that substance or set of substances which disengages the most heat." Or we may conveniently adopt Becker's extension of the law,[2] formulated thus: "The transformations will be such as to evolve heat, light, etc., at the highest possible rate."

Now the "heat of solution" of a salt in water is in some cases positive, in others negative; but we may fairly assume that the crystallization of a mineral from an igneous rock-magma is in general attended by the evolution of a considerable amount of heat, perhaps something of the same order as the latent heat of fusion of the mineral by itself. Hence, in a magma near the point of saturation, whatever promotes crystallization will promote the most rapid evolution of heat. In an unequally heated magma this must be effected by the accumulation of the least soluble ingredients in the part most easily saturated; that is, the concentration of the iron-oxide, etc., in the coolest region, and their crystallization there. It seems probable that the only practical limit to this action will be fixed by the growing viscosity of the magma, which, as follows from Vogt's[3] results, will be increased by the abstraction of the iron-oxides and other basic ingredients.

According to the view here offered, the Soret action, operating during the earlier stages, would bring about only a small part of the differentiation finally established. In consequence of it, and of the lower temperature of the reservoir towards the margin, the marginal portion of the magma would, as the whole cooled, be the first to become saturated, say with iron-oxides. At this point the further action to which I have drawn attention would come into play, and might produce much greater concentration of the iron in the outer part of the intrusion.

[1] Mécanique Chimique, vol. i. p. xxix.
[2] Amer. Journ. Science (3), vol. xxxi. p. 191.
[3] Zeits. f. prakt. Geol. vol. i. p. 275 (1893).

NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE THE BRITISH ASSOCIATION, NOTTINGHAM, SEPTEMBER, 1893.

I.—ON THE BASE OF THE CAMBRIAN IN WALES. By H. HICKS, M.D., F.R.S., F.G.S.

IF there be, as has been maintained by the author and others, a very marked unconformity at the base of the rocks usually classed as Cambrian in Wales, the evidence furnished by an examination of those basal beds which indicate shore conditions is of the utmost importance. The author, therefore, in this paper gives a summary of the results bearing on this question which he has obtained in his examinations of these rocks in Wales.

PEMBROKESHIRE.

St. Davids.—The basal beds are exposed on the north and south sides of the pre-Cambrian Axis. Where faults do not intervene the lowest beds are rough conglomerates from 60 to 150 feet in thickness, in which pebbles over a foot in diameter are very frequently met with. The matrix and pebbles vary constantly, as they rest on different parts of the pre-Cambrian Axis, and there is the clearest evidence of an unconformity between the conglomerates and the highest beds of the Pebidian in this area. The overlying beds, which are grits and sandstones, are ripple-marked and show other proofs of having been deposited in shallow shore-water. The author has recently re-examined the basal beds in this area, and has accumulated additional evidence in support of the above view.

Ramsey Island.—The Cambrian conglomerates here rest on pre-Cambrian felstones and breccias. The pebbles are mainly well-rolled fragments of felstones cemented together by a felsitic matrix. Pebbles of quartzite and other materials are occasionally found, but the main amount of the material was undoubtedly derived from the rocks immediately underlying the conglomerates. The underlying rocks had undergone the marked changes now visible in them before the fragments in the conglomerates had been broken off.

Trefgarn.—The pre-Cambrian rocks in this area are mainly felstones of a peculiar type and volcanic ash. The conglomerates which repose on these rocks contain pebbles of large size, which have been proved by microscopical examination to be identical in character with the rocks on whose eroded surface they repose. Here again the marked similarity in the minutest particulars between the rolled fragments and the underlying rocks proves indisputably that the peculiar changes which these rocks have undergone must have taken place before the fragments were broken off, therefore in pre-Cambrian times.

MERIONETHSHIRE.

Harlech Mountain.—Near the centre of the well-known anticlinal of Cambrian rocks in the Harlech Mountain conglomerates are exposed which contain fragments of granitoid rocks, felstones, etc., in addition to pebbles of quartzites and quartz, and it is clear that

they are, though not actually at the base, yet very near the base of the Cambrian rocks of that area. The most important conglomerates, however, in this district are those which were discovered by Professor Hughes and the author on the east side of the Trawsfynydd Road, between Cae Cochion and Penmaen. Here the conglomerates rest unconformably upon an older series of rocks, and large fragments of the latter occur plentifully in the conglomerates.

ANGLESEY.

As Sir A. Geikie has recently admitted that many of the rocks in Anglesey, coloured on the Geological Survey Map of that island as "altered Cambrian (and partly Silurian)," are "undoubtedly far older than at least any of the Cambrian rocks of Anglesey or Caernarvonshire," the evidence furnished by the basal beds where they rest on these rocks is highly important. The author was the first to point out, in a paper read before the British Association in 1879, that the patch near the centre of Anglesey coloured as "intrusive granite chiefly of Lower Silurian age" contained within its boundary rocks of pre-Cambrian age, evidently the oldest rocks in the island. (The rocks in this patch Sir A. Geikie now says appear to him to be "unquestionably Archæan.") In the year 1884 the author further showed that the Cambrian conglomerates near Llanfaelog contained large pebbles of granitoid and other rocks, which, on microscopical examination, proved to be identical with rocks *in situ* in their immediate neighbourhood.

Professor Hughes has shown by fossil evidence that the beds which overlie the conglomerates near Llanerchymedd are of Upper Cambrian age, and, as these are separated by faults from the conglomerates and grits, it is clearly justifiable to classify these beds as the basal beds of the Cambrian in that area. The basal Cambrian beds near Beaumaris furnish equally convincing proofs of proximity to a shore-line composed of pre-Cambrian schists and felsitic rocks.

CAERNARVONSHIRE.

Bangor and Caernarvon.—The basal beds at and near Caernarvon described by Professor Hughes show clearly that they must have been deposited along a shore-line where granitoid and felsitic rocks were undergoing denudation, and the absence there of the usual thickness of overlying Cambrian rocks is due, the author believes, mainly to faults, but in part also to the unevenness of the pre-Cambrian land-surface. There is much evidence in the various areas to show that the pre-Cambrian land-surface was very uneven in character, and that the Cambrian sediments were accumulated along fairly well-defined lines of depression.

Bethesda, Llyn Padarn, and Moel Tryfaen.—The basal beds of the Cambrian in these areas, where not removed by faults, are also conglomerates, and the fragments in the conglomerates are mainly such as would be derived by denudation from the ridge of rocks in the neighbourhood which had been claimed by the author and Professor Hughes as of pre-Cambrian age. These views, put forward

by them in the year 1877, were not accepted by the chiefs of the Geological Survey; but in the year 1891, in his anniversary address to the Geological Society, Sir A. Geikie admitted that the rocks in this ridge, "variously termed quartz porphyries, felsites, and rhyolites," were not intrusive in the Cambrian rocks, as marked on the Survey Maps, but "the oldest members of the volcanic series," and that "there is no true passage of the sedimentary rocks into it; on the contrary, the conglomerates which abut against it are in great part made out of its fragments, so that it must have been already in existence before these Cambrian strata were deposited."

The grits and slates which overlie the conglomerates in these areas have always been classed by the Geological Survey as Lowest Cambrian; therefore any attempt on the part of the Geological Survey to extend the term Cambrian so that it might include the much older rocks which the surveyors had incorrectly marked as intrusive, and "chiefly of Lower Silurian age," the author thinks is unwarrantable. The error which caused the surveyors to class other pre-Cambrian rocks as "altered Cambrian" equally renders it impossible to group those with the Cambrian, especially as in no instance has it been shown that the so-called "altered Cambrian rocks" have their equivalents amongst the unaltered Cambrian rocks of the Survey. Moreover, it is certain that there is a marked unconformity at the base of the Cambrian (unaltered Cambrian of the Survey) in all the areas in Wales where the beds are seen to rest on the rocks classed by the author and others as of pre-Cambrian age.

II.—Notes on a Hornblende-Pikrite from Greystones, Co. Wicklow. By W. W. Watts, M.A., F.G.S. [Communicated by permission of the Director-General of the Geological Survey.]

IN this paper the author gave a description of a rock which forms a dyke in the Cambrian slates and grits of Greystones, in Co. Wicklow. It is a dark, dense, coarsely-crystalline rock, showing large crystals of hornblende with lustre-mottling, owing to the weathering-out of olivine crystals. It becomes finer-grained at the margins. An analysis by Dr. Sullivan was added.

The hornblende is of the usual green type, and occurs in large crystals enclosing pseudomorphs of olivine, now made up of magnetite and probably a colourless amphibole. A colourless hornblende also occurs either as cores or borders to the green crystals. A third type of hornblende present shows few cleavage cracks and much magnetite dust. Apatite is a constituent, but there is no felspar in the rock. The margin of the dyke is much sheared and phacoidal in structure.

III.—Notes on the Perlitic Quartz Grains in Rhyolite. By W. W. Watts, M.A., F.G.S. [Communicated by permission of the Director-General of the Geological Survey.]

THE author exhibited specimens of that variety of the Sandy Braes Rhyolite from County Antrim which was formerly called Perlite. A microscopical examination of the rock shows crystals

of sanidine and grains of quartz embedded in a brown glass. The latter shows perlitic structure in great perfection. In addition, however, the grains of quartz exhibit a series of cracks, which are distinctly perlitic in character. Thus a structure which was supposed to be confined to glasses that have cooled rather rapidly is shown to occur rarely, but occasionally, in crystals. Hitherto only one case has been observed in which the cracks entered from the crystals to the matrix; the perlitic cracks in the two constituents are for the most part independent.

IV.—On the Minute Structure of the Skeleton of "Monograptus Priodon." By Professor W. J. Sollas, D.Sc., F.R.S. [Communicated by permission of the Director-General of the Geological Survey.]

REMAINS of *Monograptus priodon* in an exceptionally perfect state of preservation occur in the Silurian limestone of Barnham Hill, Co. Tipperary, and are exhibited in the official collection of the Geological Survey in Dublin. These have been examined in thin slices under the microscope, and as a preliminary result the author describes the structure of the wall.

Most of the sections are transverse and display the cœnosarcal canal and one hydrotheca; they measure a little over 1·5 mm. along the greater, and about 1 mm. along the shorter axis. The wall, 0·025 mm. in thickness, consists of black carbonaceous material in a more or less fragmentary condition, but sufficiently continuous to enable the existence of three layers to be determined: an outer and inner, which are very thin, separated by a space, now filled with calcite, from a thicker middle layer, which measures from 0·005 to 0·001 mm. across. The middle layer sometimes breaks up into threads, and the superficial films have a reticular appearance, which may, however, be due to *post-mortem* changes. In the region of the virgula and also along the free edges of the thecæ the wall thickens, partly by an enlargement of the space between the layers, and partly by a thickening of the middle layer. Thus, in one example the total thickness of the wall in the virgular region is 0·075 mm., and of the virgula itself, which represents the middle layer, 0·037 mm.; similarly at the margin of the theca the total thickness was found to be 0·085 mm., the included middle layer measuring 0·045 mm. Thin threads of carbonaceous material extend from the middle to the superficial layers, and are particularly obvious in the thickened regions. The virgula would appear to possess no independent existence; it seems to be merely a thickening of the middle layer.

V.—On the Origin of Intermediate Varieties of Igneous Rocks by Intrusion and Admixture, as observed at Barnavave, Carlingford. By Professor W. J. Sollas, D.Sc., F.R.S.

THE two principal kinds of Rocks composing the mountain of Barnavave are a dark-coloured, almost black, gabbro and a light-coloured, almost white, granophyre. This extreme contrast in

colour renders the study of their relations to each other in the field a comparatively easy task. The gabbro, which overlies the granophyre, was the first-formed rock, and had already cooled and solidified before the granophyre was injected into it. The injection of granophyre has been of the most searching character, and the rock can be traced from the parent mass through dykes of all gradations in size down to the minutest films and specks which fill cracks and cavities in and amongst the constituent minerals of the gabbro. The gabbro has thus become converted locally into the quartz gabbro of authors, and it is suggested that in other cases, as that of Carrock Fell, this rock has had a similar origin. The granophyre, on the other hand, contains fragments of the gabbro, ranging from great blocks down to mere crystal dust of its constituent minerals, labradorite and augite. It thus passes into hornblendic granophyre, the "syenite" of the Survey. There is no evidence here, as has been erroneously supposed, of the differentiation of an originally homogeneous magma, and the minute granophyric dykes are neither contemporaneous nor segregation products. On the contrary, rocks of intermediate character have been produced from already differentiated and opposed types solely by admixture.

VI.—On the Discovery of a Concealed Ridge of pre-Carboniferous Rocks under the Trias of Netherseal, Leicestershire. By Professor Edward Hull, LL.D., F.R.S., F.G.S.

IT is now generally recognised that the Leicestershire and Warwickshire Coal-measures were deposited along the borders of a land surface of older Palæozoic rocks, of which the visible representatives occur at Charnwood Forest and Atherstone. The attenuated condition of the Lower Carboniferous beds at Calke Abbey on the north of the Leicestershire Coalfield, and their entire absence below the Coal-measures of Warwickshire, show that these older rocks remained unsubmerged till the commencement of the Upper Carboniferous period, when they were gradually overspread, as the land became depressed, by successive deposits of the Coal period. The general north-westerly trend of these old foundation rocks, both at Charnwood Forest and Atherstone, appears to indicate that this old land was composed of a succession of ridges and furrows running in N.W. and S.E. directions; but as the country is for the most part covered by Triassic strata the position of such ridges and hollows can only be determined by experiment. One of these ridges appears to have been in this manner determined at Netherseal Colliery in a boring put down for the purpose of determining the extension of "the main coal." Having been invited by Mr. G. J. Binns, F.G.S., the manager of the colliery, to give my opinion regarding the age of the beds passed through in the lower part of the boring, I visited the colliery and inspected the cores which were brought up and were arranged in their order of relative depth at the works. The following is an abstract of the strata passed through:—

Trias . .	*Bunter Sandstone*; light reddish-brown, pebbly sandstone; 262 feet.
Coal-measures	Grey and black shales and sandstones, with coal and ironstone; plants abundant; 514 feet.
Pre-Carboniferous	Reddish, purple and grey grit, sandstone and micaceous quartzite; 19 feet.

The interest attaches to the beds called "pre-Carboniferous." They consist of sandstones, grits, and quartzites, of purple and yellowish tints, occasionally shaly. They contrast strongly with the Coal-measures, not only in the absence of beds of coal, grey and black shale, and ironstone, but also in the complete absence of plant remains with which the overlying Coal-measures are crowded; not one solitary instance of any plant-form having been found amongst all the cores after careful examination. It became clear that the beds were not of Carboniferous age, yet it was very difficult to determine with certainty to what period they were to be referred. Such sandstones, grits, and quartzites might be found in several pre-Carboniferous formations, either the Old Red Sandstone, the Upper Silurian, Lower Silurian (Ordovician), or Cambrian. A reference to the Old Red Sandstone was considered out of the question, as this formation is not found anywhere in this part of England; nor did it seem probable that they were referable to the Upper or Lower Silurian period, though this is possible. On the other hand, we could not forget that at no great distance to the south of the boring Lower Cambrian beds form the floor of the Coal-measures, and, although the cores at Netherseal boring did not show a very strong resemblance to those of the Hartshill ridge, there was no good reason why they might not be referable to the same general period, and consist of beds not visible in that locality. For these reasons I am disposed with some hesitation to regard the cores as of Lower Cambrian age, a view in which I am supported by Professor Lapworth, who was kind enough to examine the specimens of the cores which I brought away with me from Netherseal Colliery. I will only add that no conclusion could be gathered regarding the question of unconformity of these beds with the overlying Coal-measures, as the dip of both series appeared to be very slight. A strong discordance could have been immediately detected.

Since the above was written No. 2 boring has entered these old rocks, and the specimens brought up confirm the conclusion arrived at from the results of boring No. 1. The rock entered at a depth of about 760 feet consists of reddish vitreous quartzite, slightly micaceous, and very similar to the Hartshill stone of Warwickshire.

VII.—Notes on the Water-bearing Capacity of the New Red Sandstone of Nottingham. By Professor Edward Hull, LL.D., F.R.S., F.G.S.

About half a century ago, before the problems of sanitation were generally understood, the town of Nottingham was placed in a most unfavourable position as regards drainage and water-supply. As regards the former the drainage of the houses

for the most part was run off into cesspools sunk in the sandstone rock on which the town is built; and as regards the latter the water-supply was drawn from wells sunk through the same formation down to the water-level, so that often the cesspools and wells were in proximity to each other. The result of such a state of affairs may easily be surmised. However excellent as a filter may be the sandstone rock, it must assuredly become clogged with fæcal matter when filtration of water is carried on for an indefinite period, subject to such contamination as is here referred to, and in course of time the water from the wells becomes unfit for drinking and household purposes.

Now all this is changed: the cesspools have been closed or filled up, and the water-supply is drawn from large and deep wells far removed from possibility of contamination.

Few towns in central England are more favourably situated for purposes of water-supply than Nottingham. Built on a foundation of New Red Sandstone and conglomerate, which rises at the Castle in a precipitous cliff above the valley of the Trent, the formation on which the city stands in its prolongation northwards is a source of water-supply of the highest excellence, and yields several millions of gallons per day of pure water from three or four wells situated within a few miles of the city.

The conditions which render this formation so well adapted for water-supply may be briefly explained. The succession and character of the strata all combine towards this end.

In descending order the succession is as follows:—

Trias	*Keuper Marls* . . .	Red and variegated marl, shaly and gypseous (slightly permeable).
	Waterstones and Lower Keuper Sandstone	Laminated micaceous sandstones alternating with marls and shales.
	Bunter Sandstone . .	Soft yellow and reddish sandstone and conglomerate (permeable).
Permian	*Red Calcareous Marls* .	These are the strata separating the Upper and Lower limestones of the Worksop district to the north (impervious).
	Lower Magnesian Limestone	Sandy magnesian limestones.

From the above succession it will be seen that the permeable beds of the Bunter Sandstone, about 300 feet in thickness, are underlain by impervious marls of the Permian series, which thus form a water-tight floor, effectually preventing the water which percolates downwards from the surface to escape into the magnesian limestone; and, as the beds dip eastwards at a small angle from the western margin of the formation, an underground reservoir is thus formed with a naturally permanent level corresponding to that of the springs which break out at the junction of the sandstone with the marl along the western outcrop.

The proportion of the rainfall, taken at an average of 30 inches, which sinks down into the Bunter Sandstone north of Nottingham must be very large, owing to the absence of drift deposits and the sandy character of the ground. As there is no surface drainage

the percolation cannot be less than about 20 inches per annum, giving a supply of about 1,000,000 gallons to every 3 square miles. Taking the area of the formation between Nottingham and Worksop at 120 square miles, the amount of water which annually percolates into the rock and becomes a reservoir of supply may be estimated at about 40,000,000 gallons per day.

This large quantity of water tends to flow eastwards, following the dip of the beds; and that it has permanently saturated the Bunter Sandstone under an extensive area occupied by the overlying formations is proved by the result of the boring at Scarle, near Lincoln, which, commencing in the Lower Lias, passed down through the Keuper marls into the Bunter, when the water came up with force and flowed over the surface.[1] This boring is at a minimum distance of 20 miles from the margin of the Bunter Sandstone. From these considerations it may be inferred that Nottingham is most favourably situated as regards its water-supply for a long period to come—a circumstance of great importance at a time when so many large manufacturing towns are looking forward with anxiety to the future as regards this prime necessary of progress and prosperity.

Since the above was written I have been favoured by Mr. L. T. Godfrey Evans, the Borough Engineer, with information, of which the following is a summary:—

There are four pumping stations, of which one, the Park, Zion Hill, is not now in use. The others are:—

1. Basford or Bagthorpe, yielding 12,800,000 gallons per week.
2. Bestwood, yielding 11,800,000 ,, ,,
3. Papplewick, yielding 12,190,000 ,, ,,

In all 36,790,000 gallons per week, or 5,257,143 gallons per day.

The supply at Bestwood is decreasing, owing probably to mining operations in the neighbourhood. The yield at the Park Station is about 5½ millions of gallons per week. The water is excellent.

VIII.—On the Reptilia of the British Trias. By E. T. Newton, F.R.S., F.G.S.

THIS communication is a review of our knowledge of the reptiles which have been recorded from the Triassic strata of Britain. In the first place attention is called to the teeth from Durdham Down, Bristol, described by Riley and Stutchbury, in 1836, under the generic name of *Palæosaurus* and *Thecodontosaurus*, which, with additional specimens, were further described by Professor Huxley in 1869, he regarding them both as dinosaurian. The two genera are distinguished by the form of their teeth. Closely allied to *Palæosaurus* is the tooth described by Murchison and Strickland in 1837 as *Megalosaurus*, but subsequently named *Cladyodon* by Owen. Another and still larger tooth, from the same neighbourhood, has been referred by Professor Huxley to *Teratosaurus* (=*Zanclodon*): it is very

[1] Two feeders of water were struck—one at a depth of 917 feet in the Lower Keuper Sandstone, and the other at 1,250 feet in the Bunter Sandstone.

similar to that of *Cladyodon*, but is more compressed and has both anterior and posterior edges serrated to the base.

Rhynchosaurus articeps, from the Keuper of Grinshill, Shropshire, was described by Owen in 1841 from a skull, but was further illustrated by additional specimens, including other parts of the skeleton, by Professor Huxley in 1887. This form, which is allied to the recent *Sphenodon*, is also near to the *Hyperodapedon*, remains of which have been found in the Elgin Sandstone and also in the Trias of Warwick and Devon. *Hyperodapedon* was first made known by Professor Huxley in 1858, who described it in 1869, but more fully in 1887, from a fine example preserved in the British Museum.

Telerpeton Elginense, the celebrated lizard of the Elgin Sandstone, was found in 1850 by Mr. Patrick Duff, and described by Dr. Mantell in 1851 as having amphibian affinities. Additional examples were, however, described by Professor Huxley in 1867, who showed that its affinities were with the lacertilia, and not with the amphibia. *Telerpeton* is probably closely related to the living *Sphenodon*. *Stagonolepis Robertsoni* was really the first reptile found in the Elgin Sandstone; a series of scutes from Lossiemouth being thus named by Agassiz just fifty years ago (1843), but were thought by him to be the scales of a fish. The reptilian nature of this fossil was shown by Professor Huxley in 1858, and more abundant material has been described by the same writer in 1875 and 1877, which has established the crocodilian affinities of this Triassic reptile.

Dasygnathus longidens is the name suggested by Professor Huxley for a jaw with long teeth from the Elgin Sandstone, which had at first been referred to *Stagonolepis*. This form Professor Huxley thought might be dinosaurian, but additional information is much wanted to establish its true affinities.

The dicynodont remains noticed by the present writer at the meeting of this Association last year at Edinburgh have now been worked out, and the results, fully illustrated, will shortly appear in the Phil. Trans. of the Royal Society. Four forms nearly allied to *Dicynodon* have been named *Gordonia Traquairi*, *G. Huxleyi*, *G. Duffiana*, and *G. Juddiana*. Another dicynodont more nearly related to the *Ptychognathus* of Owen, but with a short muzzle and no teeth, has been named *Geikia Elginensis*.

The peculiar horned reptile, resembling the Moloch lizard, but apparently most nearly related to the South African *Pareiasaurus*, has been named *Elginia mirabilis*.

Work among the Elgin reptiles is still going on, and two entirely new forms are now made known for the first time. One of these was found by Mr. James Grant, of Lossiemouth; and, although the exact locality is uncertain, there is no doubt as to its being from the sandstone of the Elgin area. This specimen, which includes the skull (about three inches long) and the fore part of the trunk, is evidently related to *Stagonolepis*.

The second new form was obtained by the Rev. Dr. Gordon from the Elgin Sandstone of Spynie Quarry, and will eventually be

preserved in the British Museum. With the exception of the fore limbs and neck, nearly the whole of the skeleton has been preserved. Much of the skull has been very successfully cleared from the matrix by Mr. Richard Hall, of the British Museum, and was exhibited at a soirée of the Royal Society, when its resemblance to *Aëtosaurus* was pointed out by Mr. Arthur Smith Woodward. This reptile is of much interest, as it seems to be an intermediate form between crocodiles and dinosaurs, being, apparently, related on the one hand to the *Parasuchia* and on the other to the theropodous dinosaurs. The skull is, in fact, that of a miniature megalosaur.

IX.—Note on some Molluscan Remains lately discovered in the English Keuper. By R. Bullen Newton, F.G.S. British Museum (Natural History).

THIS communication directs attention to the discovery, by the Rev. P. B. Brodie and Mr. E. P. Richards, of some obscure impressions of lamellibranch shells in the green gritty marls of the Upper Keuper Sandstone of Shrewley, Warwickshire, which form the first evidence of a molluscan fauna from these beds as developed in this county. The matrix appears to be so peculiarly unfavourable for the retention of shell structure that it is doubtful whether any better material than the present will ever be forthcoming. The specimens indicate truly marine types, though on account of bad preservation only three of them could be selected for description as exhibiting certain characters in their contours and sculpturing, which might be of service in ascertaining their probable generic positions. *Estheria minuta* is the one invertebrate form hitherto recorded from the British Keuper; that is, excluding the Foraminifera described by Professor T. R. Jones and W. K. Parker,[1] which came from an alabaster pit at Chellaston, near Derby, and which were doubtfully referred by the authors to an Upper Triassic age. The very modern facies of the Foraminifera has suggested the highly probable idea that they were derived from superficial deposits.

Associated in the matrix containing these molluscan impressions are fragments of Cestraciont spines and teeth (*Acrodus Keuperinus*) and a part of a carapace of the small phyllopodous crustacean, *Estheria minuta*.

The specimens described are identified as—

(1) *Thracia* (?) *Brodiei* (n. sp.).
(2) *Goniomya Keuperina* (n. sp.).
(3) *Pholadomya* (?) *Richardsi* (n. sp.).

Such generic forms as are represented here have not apparently been reported from rocks of a similar period on the Continent or elsewhere.

[1] "On some Fossil Foraminifera from Chellaston, near Derby," Quart. Journ. Geol. Soc., 1860, vol. xvi. pls. 19, 20, pp. 452—458.

X.—On the Radiolarian Cherts of Cornwall. By Howard Fox, F.G.S.

THE Mullion Island Radiolarian cherts were first recognized by Mr. J. J. H. Teall, F.R.S., in rocks sent to him by the author last autumn, and a joint paper was read at the Geological Society's meeting, February 8 last, describing the manner in which they occur. Dr. Hinde accompanied the paper with a description of the species recognized and with micro-photographs of the individual organisms.

Last Easter Mr. Teall, Professor Lapworth, and the author traced these cherts for about 650 yards in the cliffs and on the foreshore from the south end of Nelly's Cove, near Porthallow, Meneage, to near Ligarath Point, south of the Nore Point. Subsequently the author has examined the coast and some inland districts between Helford River and Fowey, and has found other exposures in the following places:—

Pendoner Beach, Veryan (for about 1000 yards).—Beds many feet thick at the west end of this beach, on which the raised beach rests. Angular fragments of chert are enclosed in the raised beach, and in one place a mass of chert and slate cliff has been thrust over it, and thus the chert appears both above and below as well as in the raised beach. Towards the eastern end of this beach the chert beds become thicker and more numerous.

Portloe Point, Veryan.—Here several beds, varying from one to six inches in thickness, are seen for 20 yards in the volcanic breccia (or "trappean conglomerate" of De la Beche) associated with some small amount of shale and grit, more or less decomposing from the presence of iron. Two small exposures are traced inland, one of which is 500 yards west of Portloe Point.

Pecunnen Cove, Gorran.—North-west of the Dodman beds of chert are seen in perpendicular thinly laminated crushed-dark slates for 60 yards, accompanied by numerous lenticules and bands of black quartzite and yellowish-grey limestone.

Inland exposures are traced at intervals in a line extending for five miles inland from Pendoner Beach in a north-east direction through the village of Veryan to Tolcarne Mill, north of St. Michael Caerhays. These cherts on the mainland are less pure than those in Mullion Island, and the structure of the individual organism is destroyed. Some specimens show signs of great shearing and crushing, and have no traces of Radiolaria; others show shearing with slight traces of Radiolaria, whilst others show no signs of crushing, and have clear round spaces, evidently due to Radiolaria. In many of the specimens examined a considerable amount of ferric oxide has been formed by the decomposition and oxidation of pyrites, and possibly also of ferriferous carbonate. At Portloe Point the chert appears to pass into quartz.

The Meneage and Veryan cherts are associated with the well-known Ordovician quartzites of those districts, and appear to lie immediately under them; but the sequence is not absolutely clear, and no typical fossils have yet been found in the shales and slates with which the cherts are interbanded.

XI.—On the Derbyshire Toadstone. By H. H. Arnold-Bemrose, M.A., F.G.S.

TOADSTONE is a local name for the igneous rocks interbedded with the Carboniferous limestones of Derbyshire. It occurs in a district of 25 by 20 miles. The upper and lower portions of a bed are sometimes amygdaloidal. The spheroidal structure is often well marked, the columnar more seldom and less perfectly. Toadstone varies very much in the amount of weathering it has undergone. It often decomposes to a sort of clay containing nodules of less altered rock, so that it has been supposed that toadstone in some localities "replaces" a bed of clay in others. For this reason, and also because of the loose way in which the word is used by miners, statements as to the number of beds of toadstone and of the presence or absence of ore in it must be accepted with reserve. Careful mapping over the whole district will be necessary to ascertain the actual number of beds. Two at least may be seen exposed in several places, and there may be three or even four beds. The Black Hillock shaft has been supposed to be one of the vents through which the toadstone came up to the surface, because the bottom of the rock was not reached. Farey, however, maintains that this bed was sunk through, and a careful examination of the mine heap and shaft shows that the dolerite is not coarse-grained, and that there is no trace of agglomerate or tuff. An occurrence of lead-ore in the toadstone of the Wakebridge mine was next described. The rock in which the ore occurred, when examined under the microscope, proved to be a decomposed olivine-dolerite. The ore was as good in the toadstone as in the limestone. That the toadstone is contemporaneous with the limestone is proved by its being interbedded with the latter, by the occurrence of stratified tuffs in various parts of the district, and by the non-alteration of the beds immediately above the igneous rock, though in one or two places a clay bed below it has been caused to assume a columnar structure.

Very many specimens have been collected from all the outcrops of toadstone, which are some fifty in number, and many of them have been examined under the microscope. The lavas consist mainly of olivine-dolerite, the augite being both in ophitic plates and in irregularly shaped grains. The rock is much more fresh and less amygdaloidal than has been generally supposed. The tuffs are in some cases well preserved, and the outlines of the lapilli very clearly defined.

XII.—The Dissected Volcano of Crandall Basin, Wyoming. By Professor Joseph Paxson Iddings.

THE writer, in exploring the north-eastern corner of the Yellowstone National Park and the country east of it, came upon evidences of a great volcano which had been eroded in such a manner as to expose the geological structure of its basal portion.

The work was carried on as a part of the survey of this region

under the charge of Mr. Arnold Hague, of the United States Geological Survey. This paper is an extract from a chapter of the final report on the Yellowstone National Park, in process of completion, and the writer is indebted to Major J. W. Powell, Director of the Survey, and to Mr. Hague, chief of the division, for permission to present it at this time in anticipation of the publication of the final report.

The area of volcanic rocks described is but a small portion of the great belt of igneous material that forms the mountains of the Absaroka range, lying along the eastern margin of the Yellowstone Park. The volcano of Crandall Basin is one of a chain of volcanic centres situated along the northern and eastern borders of the Yellowstone Park, which are all distinguished by a greater or less development of radiating dykes, and by a crystalline core eroded to a variable extent.

The Palæozoic and Mesozoic strata, which formed an almost continuous series to the coal-bearing Laramie, had been greatly disturbed, and almost completely eroded in places, before the volcanic ejectamenta in this vicinity were thrown upon them. The period of their eruption is therefore post-Laramie, presumably early Tertiary.

The first eruptions of andesite were followed by those of basalt in great quantities, and these by others of andesite and basalt, like the first. This was succeeded by a period of extensive erosion, reducing the country to nearly its present form. Then came the eruption of a vast flood of rhyolite, constituting the Park Plateau, which was followed, in this region, by smaller outbreaks of basalt. The last phase of volcanic activity is found in the geysers and fumaroles which have rendered the region famous.

The volcano of Crandall Basin consists chiefly of the first series of basic andesites and basalts. The earliest acid andesite which occurs beneath these rocks appears to be the remnant of eruptions from neighbouring centres.

Nothing remains of the original outline of the volcano. The district is now covered by systems of valleys and ridges of mountain peaks that rise 2,000 to 5,000 feet above the valley bottoms. The geological structure of the country, however, makes its original character evident.

The outlying portions of the district to the south, west, and north consist of nearly horizontally bedded tuffs and subaërial breccias of basic andesite and basalt. With these are intercalated some massive lava-flows, which are scarce in the lower parts of the breccia, but predominate in the highest parts above an altitude of 10,000 feet. Here they constitute the summits of the highest peaks.

In contrast to the well-bedded breccias around the margin of the district the central portion consists of chaotic and orderless accumulations of scoriaceous breccia with some massive flows. These breccias carry larger fragments of rock and exhibit greater uniformity in petrographical character.

A still more noticeable feature of the central portion of the district

is the occurrence of dykes, which form prominent walls, and may be traced for long distances across the country.

The greater number of them converge towards a centre in the highest ridge in the middle of the drainage basin of Crandall Creek. A small number converge towards a second centre three or four miles east of the first. In the southern part of the district there are many dykes trending towards a centre near the head of Sunlight Basin, about fifteen miles south of the Crandall centre.

The centre towards which the Crandall dykes converge is a large body of granular gabbro graduating into diorite. It is about a mile wide, and consists of numerous intrusions penetrating one another, and extending out into the surrounding breccia, which is highly indurated and metamorphosed in the immediate vicinity of the core. Within the area of indurated breccia the dyke-rocks become rapidly coarser-grained as they approach the gabbro core. This was undoubtedly the central conduit of an ancient volcano, the upper portion of which has been eroded away.

Upon comparing the geological structure of this region with that of an active volcano like Etna it is apparent that the lava-flows which form the summits of the outlying peaks must have been derived from lateral cones fed by dykes radiating from the central conduit; and, assuming that the volcano of Crandall Basin was similar in type to that of Etna, an idea of its original proportions is derived by constructing, upon profile sections through the Crandall core, the outline of Etna. If the erosion of the summits of the highest peaks is neglected the resulting height of the ancient volcano above the limestone floor is estimated at 13,400 feet. This is undoubtedly too low, and is well within the limits of present active volcanoes.

Erosion has removed at least 10,000 feet from the summit of the mountain to the top of the high central ridge in which the granular core is situated, and has cut 4,000 feet deeper into the valleys on either side. It has prepared for study a dissected volcano, which, it is hoped, will in time reveal some of the obscurer relationships existing between various phases of igneous rocks.

XIII.—Geological Sketch of Central East Africa. By Walcot Gibson, F.G.S.

THE tract of country described in this paper is situated in Equatorial East Africa. It extends from the coast inland to the N.W. borders of Victoria Nyanza.

The small island of Mombasa, the starting-point of the expedition, lies fifty miles north of the island of Pemba. A narrow creek, fordable at low water, separates the island from the mainland.

The sea cliffs are composed of coral rock, which also forms an inland belt about two miles broad, with a general elevation of 50 feet, which sometimes rises to 100 feet. A fringing reef borders the coast. The shore sand consists of comminuted corals and shells mixed with rounded fragments of quartz, orthoclase, garnets, and splinters of clear blue cyanite. These constituents appear to be

derived from a submerged ridge, of which the Seychelles Islands are a remnant.

The coral rock rests on a sedimentary series consisting of shales, limestones, flaggy sandstones, grits, and conglomerates in descending order. The beds dip gently to the east. They extend inland to the borders of the Taru Plain, a distance of about forty-seven miles.

The beds are of marine origin, Ammonites and Ichthyosaurian remains having been found near Rabai and other localities.

It is impossible to correlate these beds with any occurring in South Africa, but they appear to form a belt running many miles north and south of Mombasa.

The sedimentary beds rest unconformably on a metamorphic series, consisting of gneisses, schists, and intrusive granites. The strike is N.N.W. and S.S.E., and the dip is generally high. The beds are often intensely folded (Ndange River). Biotite is the commonest mica, and orthoclase the predominant felspar. The schists contain much cyanite, full of iron inclusions. Common garnets are plentiful. Hornblendic rocks are remarkably scarce, the main mass being micaceous. Graphite schists occur, and the Bura Hills are largely composed of a crystalline limestone containing scales of graphite. No fossils could be detected. Quartz veins and quartzites are only feebly developed. They form gently undulating country or else nearly level plains (Taru, Serengeti) through which low isolated hills of gneiss and granite protrude.

It is evident that they have suffered enormous denudation. They no doubt represent a complex metamorphosed series of sediments and intrusive rocks, but of what geological age or ages it is impossible to state.

The intrusive granites are generally pegmatites. Porphyritic granite covers a large area in Kavirondo. Biotite is the essential mica, and a pink orthoclase the predominant felspar. The relation of this large mass of granite to the gneisses and schists could not be ascertained.

The area covered by granite and metamorphic rocks is enormous. Fully two-thirds of Central East Africa are composed of these rocks. The remaining portion of the country, excepting the narrow coast belt of sedimentary rocks, is formed of recent volcanic rocks.

No traces of the fossiliferous sandstones and shales found by Professor Drummond near Lake Tanganyika, and quite recently by Mr. Joseph Thomson to the west of Lake Nyassa and around Lake Bangweolo, were detected. If further investigation proves their absence from East Africa to be a fact, then we have in the deposits around Lake Tanganyika the most northerly extension of the Karoo beds of South Africa.

Volcanic rocks form the grandest scenery in East Africa. They occur in two forms, giving rise to two distinct types of scenery. They have either built up tall isolated mountains like Kilimanjaro (19,718 ft.), Kenia (18,000 ft.), Elgon (14,000 ft.), Chibchangani (12,000 ft.), besides numerous other smaller hills, or they are arranged in lines running north and south. The lavas, tuffs, and

ashes composing the high central plateaux of Mau, Kamasia, and Lykipia have evidently issued from a north and south fissure. The site of this fissure is now occupied by the chain of lakes commencing with Naivasha on the south, and terminating northward in Lake Baringo. Along this line recent eruptions, some still giving out steam, have broken out, and it is the interception of the drainage by the material thrown out from these vents that forms the lakes Naivasha, Nakuru, and Elmeteita.

Highly acid and ultra-basic rocks are represented. Kilimanjaro and the Kyulu Mountains are chiefly built up of basic rocks, while the lavas of Lykipia and the Mau plateaux are chiefly acid. It appears that the latter localities have been the seat from which acid lavas have continued to be poured from times prior to the first eruptions of Kilimanjaro up to the present day.

The basic lavas of Kilimanjaro do not extend very far from the original point of issue. At least this is so to the north, for no lavas were found on the plains of Lytokitok, distant thirty miles north of Kilimanjaro. On the other hand the acid lavas of Mau and Lykipia extend for great distances. Eastwards they stretch as far as the Athé plain, about fifty miles, and westwards to near the shores of Victoria Nyanza, a distance of nearly one hundred miles.

Further westward, in Busoga and Buganda, basic igneous rocks pierce the metamorphic rocks, but without possessing any general trend.

With the exception of the still active volcanoes it is impossible to state even the approximate geological age of any of the eruptions. Some of the volcanoes are possibly only dormant, others are certainly extinct, but none appear to be of great geological antiquity. All that can be safely asserted is that they are long subsequent to the deposition of strata containing *Ammonites*, for, whereas the conglomerates of these sedimentary deposits contain pebbles of schist and gneiss, they nowhere yield fragments of igneous or volcanic rocks.

REVIEWS.

I.—Note sur les Gîtes de Phosphate de Chaux des environs de Fresnoy-le-Grand. Par M. Gosselet. Annales de la Soc. Géol. du Nord, vol. xxi. 1893, pp. 149–159.

IN this paper Prof. Gosselet describes the position and mode of occurrence of some newly opened deposits of phosphate of lime near Fresnoy-le-Grand, in the north of France. The workable deposits do not extend over areas of more than from five to ten acres in each locality, they occur in a zone of Gray Chalk of from $1\frac{1}{2}$ to 2 metres in thickness, containing *Belemnitella quadrata*, *Ventriculites* and sharks' teeth. The phosphate is partly in the form of concretionary nodules, which are so numerous as to form a sort of conglomerate in the lower portion of the bed; the phosphate varies in amount from 9 per cent. to 27 per cent. The Gray Chalk rests on White Chalk with *Micraster coranguinum*, and the upper part

of this latter is penetrated just below the line of junction for about 1 m. in depth, by pockets and branching cylindrical or elliptical pipes filled with rich phosphatic chalk, and in places there is an apparent breccia between the two beds, in which the fragments of White Chalk have sharp angles, and form but a small proportion of the whole mass.

The gray bed of phosphatic chalk is overlaid in places also by White Chalk in which there are likewise some grains of phosphate, in places by Tertiary deposits. In some areas the gray bed crops out near the surface, and it then sometimes contains pockets of phosphatic sand.

II.—Republication of Conrad's Fossil Shells of the Tertiary Formations of North America. By G. D. Harris. (Washington, 1893.)

Republication of Conrad's Fossils of the Medial Tertiary of the United States. With an Introduction by Dr. W. H. Dall. (Philadelphia, 1893.)

In republishing the above works of Conrad, Messrs. Dall and Harris have rendered an immense service to students of the Mollusca. The first mentioned book was published in parts, which only exist at the present day in a more or less fragmentary condition. The dates of their issue were practically unknown until Dr. Dall, with infinite pains and research, succeeded in establishing the same;[1] whilst Mr. Harris was subsequently enabled to make some further notes thereon.[2] The former author remarks that "Mr. Conrad had several peculiarities; he wrote his letters and labels frequently on all sorts of scraps of paper, generally without date or location. He was naturally careless or unmethodical, and his citations of other authors' works cannot safely be trusted without verification, and are usually incomplete. He had a very poor memory, and on several occasions had re-described his own species. This defect increased with age, and, while no question of wilful misstatement need arise, made it impossible to place implicit confidence in his own recollections of such matters as dates of publication."

Conrad's method of publication, too, was slovenly in the extreme. The "Medial Tertiary" volume, also issued in parts, had blank spaces left on the covers for the purpose of filling in the number of each part and the date of its publication—these particulars being written with a pen, presumably by the author. Sometimes when there were a few diagnoses over, enough to fill a "signature" of 8 or 16 pages, the excess was printed on the cover, and occasionally the cover of one and the same part was twice surcharged. It would seem from Dr. Dall's observations that the sheets were kept on hand and made up into a volume when called for from time to time by the subscribers. In regard to the plates in the work, it appears that, owing to the vagaries of the authors, there is at least one plate

[1] Bull. Phil. Soc. Wash. vol. xii. (1893), pp. 215–239.
[2] American Geologist, vol. xi. (1893), p. 279.

which is not the original, but a substitute, in nearly every copy extant.

Many of the fossils are re-figured and partially described by the Marquis de Gregorio[1]—those from the Middle Eocene of Claiborne, Alabama—but the drawings are not well done. In the two works under review we have *fac-simile* illustrations, whilst the text is a "Chinese copy" of Conrad's own. The only additions are the editors' introductory remarks and a useful index of genera and species to each volume.

III.—Report on the Bendigo Gold-Field. By E. J. Dunn, F.G.S. Folio, pp. 20, with numerous Plans and Sections. (Melbourne, 1893.)

THIS is one of the "Special Reports" of the Department of Mines, Victoria. The object kept in view in this elaborate and well illustrated Report, by the painstaking Surveyor, is to indicate the direction and the extent, both longitudinal and transverse, of the known "reefs," or lines of outcrop and underground foldings, of the gold-bearing rocks, so that the miners might carry on their operations not empirically, but with a real knowledge of the relative position of these rocks, whether seen or not at the surface, or in the existing mines and borings. Thus the miner may often make sure of working progressively for a considerable distance ahead of his present shaft and adits, along the axial lines of the anticlines and synclines, now here indicated by clear plans and sections, as well as where and how to follow the slopes ("lines of pitch") of the bent or folded strata with advantage.

The special rocks of these saddles and troughs being known, they can be recognized in the "cross-cuts," and "it will be possible to locate the precise zones of rocks through which work is contemplated over the whole field."

Had such practical geological knowledge as is here placed at the command of the miners been appreciated and possessed by them, in Australia and elsewhere, in time past, it would have saved enormous waste of time, labour, and lives.

IV.—Lehrbuch der Petrographie. Von Dr. Ferdinand Zirkel; Zweite gänzlich neu verfasste Auflage. Erster Band. Leipzig (Wilhelm Engelmann), 1893.

THE twenty-seven years, which have elapsed since the last edition of this important work was published, have been extremely prolific so far as writings on petrographical subjects are concerned. It is, therefore, not surprising to find that the present edition, which is to consist of three volumes, will largely exceed the last in size. If the second and third volumes are each equal to the one now before us, then the new edition will contain three times as much matter as the old one. This increase in size is certainly not out of proportion to the increase in our knowledge.

[1] Ann. de Géol. et Pal. (Palermo), 7e and 8e liv. (1890).

The brilliant results achieved by the application of the microscope to the study of rocks led, at first, to the comparative neglect of the older methods of investigation; but the time has passed by when the description of the microscopic characters of isolated rock-specimens can be of much value. The microscope has now to be employed in conjunction with the chemical balance, and both must be brought to bear on rocks whose relations with other rocks have been carefully studied in the field. Petrographical students will, therefore, cordially welcome the appearance of a work in which rocks are to be treated from all points of view. Professor Zirkel has set himself the task of recording the present state of petrographical science. He has an extensive acquaintance with rocks, both in the field and in the laboratory, and an unrivalled knowledge of the literature of the subject. He is, moreover, in other respects eminently qualified to carry out the work he has taken in hand, and there can be no doubt that the present edition of his well known treatise will be constantly consulted by all those who are engaged in petrographical research.

The first part deals with General Petrography. The methods employed in the investigation of rocks are first described. Then follows an account of the mode of development of the constituents and a detailed description of each of the important rock-forming minerals. The information on these topics is brought well up to date, and there are copious references to original papers.

Rock-structures and the mode of occurrence of rocks as parts of the earth's crust are next considered; and, after describing the various agencies by which rocks are altered, the author concludes the first part of his work with a broad general classification.

As regards the technical terminology of the science, the author is content in most cases to accept the terms already in use. He, however, frequently objects to those employed by Rosenbusch. Thus instead of *idiomorphic* and *allotriomorphic*, which are extensively employed both in Germany and in English-speaking countries, he prefers the older terms *automorphic* and *xenomorphic* first proposed by Rohrbach. He also protests strongly, both on historical and etymological grounds, against the use of the term *granophyre* in the sense in which it is employed by Rosenbusch. It must be admitted that there is great force in many of his arguments; but, after all, the main object of language is to convey clear and definite ideas, and if this result be obtained there are many who are prepared to tolerate a little historical injustice and even some etymological inaccuracy. No scientific man ever dreams of arriving at the meaning of a technical term by considering its etymology.

The author separates rocks into four groups for descriptive purposes:—

I. Massive eruptive rocks.

II. Crystalline schists.

III. Sedimentary rocks with crystalline (at least not clastic) structures.

IV. Clastic rocks.

This is probably as good a classification as any that could be devised. Inasmuch as rocks do not fall into sharply-defined natural groups, it is impossible to invent a classification against which objections may not be urged.

The subjects referred to above occupy three-fourths (635 pages) of the present volume. The remainder forms an introduction to the detailed study of the igneous rocks. Mode of occurrence is first discussed, and it is satisfactory to note that the true significance of the contrast in structure between the volcanic and plutonic rocks is clearly recognized. The attempt of Rosenbusch to raise the dyke-rocks to the position of a group, comparable in importance to the plutonic and volcanic groups, is unfavourably criticised. The minerals which enter into the composition of igneous rocks are next considered, especially with reference to the laws of association. Microscopic research has led to important modifications in the old ideas as to paragenesis, but there are many laws relating to the association of minerals which possess a sufficient amount of generality to make them worthy of most careful consideration.

The chemical relations of igneous rocks are discussed at length, and the views of Bunsen von Waltershausen, Durocher, Rosenbusch, H. O. Lang, Lagorio, Iddings, and others are fully described and critically examined. The phenomena attending the consolidation of igneous magmas are most carefully considered and the constituents are classified as follows, with regard to their order of development:—

1. Minerals foreign to the eruptive magma.
2. Minerals produced before the normal consolidation of the mass; *e.g.* quartz in quartz-basalts.
3. Minerals due to the action of the magma on the constituents belonging to 1 and 2.
4. Minerals formed as products of normal consolidation.
5. Minerals formed during the last stages of consolidation, which, however, can scarcely be regarded as belonging to the ordinary processes of consolidation; *e.g.* tridymite and fayalite in lithophysæ in obsidian, etc.
6. Minerals which do not belong to any of the above categories, and which cannot be referred to 7 with certainty.
7. Minerals produced in the rocks after consolidation by secondary agencies, or deposited in cavities by infiltration.

In dealing with the classification of the igneous rocks, the author lays down the general principle that mineralogical composition and structure are the two factors of primary importance. He thinks that geological age may still be employed in certain districts, and no doubt he is right; but whether it is desirable so to employ it in a general classification is a question on which difference of opinion still exists. The classification ultimately adopted is very similar to that of the first edition, except that geological age is relegated to a secondary place. The felspathic constituents are used as the means of defining the principal subdivisions, and three main groups are recognized. The first includes the rocks characterized by the predominance of alkali-felspars, the second those characterized by lime-

soda-felspars, and the third those containing no felspar. These are further subdivided according to the presence or absence of quartz and the nature of the felspathic and ferro-magnesian constituents. Two main divisions—the granular and the porphyritic (including glassy) — based on structure are recognised. These correspond approximately, but not exactly, with the plutonic and volcanic divisions of other authors. Geological age is introduced, as in the Rosenbusch classification, only with reference to the volcanic rocks. The limitation of the terms rhyolite, andesite and basalt to rocks of the Tertiary and post-Tertiary periods will strike anyone acquainted with British rocks as very strange and unnatural.

The value of this work, however, does not depend on the classification which is adopted or on the terminology employed; but on its being an encyclopædic record of the present state of petrographical knowledge. In many cases the student will find here all that he wants, but if not he will have no difficulty in obtaining references to the original communications bearing on the subject in which he is immediately interested. The second and third volumes are promised within a month or two.

V.—Observations and Experiments on the Fluctuations in the Level and Rate of Movement of Ground-water on the Wisconsin Agricultural Experiment Station Farm, and at Whitewater, Wisconsin. By Prof. Franklin H. King, United States Department of Agriculture, Weather Bureau, Bulletin No. 5 (1892). 75 pp., six plates.

THE experiment farm lies on the south side of Lake Mendota, in Wisconsin. The ground rises from the level of the lake to about fifty feet above it, within the area in which the wells are situated, and just outside that area to a height of 111 feet. The farm is situated on Till, resting on an uneven surface of Madison sandstone. All over the surface of the ground there is a layer of reddish clay, $2\frac{1}{2}$ to 4 feet thick, containing pebbles and boulders sparsely scattered, which passes rather rapidly downwards into a nearly uniform sand. The wells are 54 in number, and the majority vary in depth from 5 to 26 feet and are made wholly in the Till, but a small number reach a greater depth and penetrate a few feet into the rock. Most of them are tubed with 5-inch drainage tile, surmounted at the surface with one length of 8-inch glazed sewer pipe with a galvanised iron cover. The height of the water in the wells was at first ascertained by lowering a weight through a distance which could be measured by a micrometer on the surface, the base of the weight being a hemispherical button which produced waves in the water at the instant of contact. Afterwards a simple recording instrument was employed, consisting of a copper float connected with the short arm of a lever, the long arm of which carried a pen which, on a scale three times the natural size, traced the fluctuations in the water-level on paper moved by clockwork.

The level at which the water stands in the wells is everywhere above that of the water in Lake Mendota. The general tendency,

as is observed in other places, is to stand highest under the highest ground, but to this there are several notable exceptions. When a prolonged dry period is followed by heavy rains, the water-surface under the low lands not infrequently stands above that under the higher areas. This is due partly to the low lands having less storage capacity on account of their smaller depth of soil, partly to the rains remaining for too short a time on the high lands to penetrate the soil. The measured height of water in a well is not always, however, a true index of the level of the neighbouring ground-water. It may be below the latter if the well be in constant use; and above it occasionally after protracted heavy rains, when the soil-air is unable to escape readily upwards through the supersaturated surface, but can be forced out of the wells, thus allowing the water to follow it.

The rate at which the ground-water rises and falls varies between rather wide limits, but, as a rule, a given rise occupies a much shorter time than the same fall. The water generally falls more rapidly in the shallow than in the deep wells, partly on account of the shorter distance to the drainage outlet making the resistance to the flow less, partly from a more rapid loss of water at the surface of the ground through combined capillary and root action. After a fall of rain the rise of the ground-water takes place almost immediately in the shallow wells, but lags behind for two or three days in the deep ones, the average rise being 0·42 foot, or about five inches, for a rainfall of one inch. The rate at which the water-level falls is much greater when the barometer is rising than when it is falling; during the three years 1888–90 the mean daily fall was 0·224 inch with a rising, and 0·001 inch with a falling, barometer. Again, the water-level falls more rapidly during the day than during the night, the average fall for a number of wells being 8·583 inches per 1000 day-hours (6 a.m. to 6 p.m.) and 1·309 inches per 1000 night-hours (6 p.m. to 6 a.m.).

The general surface of the ground-water is also subject to numerous oscillations of small extent, some of which are almost microscopic in amplitude, so that it is rare for it to be ever quite at rest. "The equilibrium of the water in the capillary soil-spaces above the surface of the ground-water is so unstable that apparently the slightest cause is sufficient to upset it, causing the water to flow out into the non-capillary spaces, but only to be returned again, often on a moment's notice. . . . . The geologic and agricultural significance of these movements must be very great, for here is a water-washed zone of rock and soil, having the combined area of all land above the ocean level, unless we must except those of the polar zones, which is alternately flooded with water and then exposed to air; and this zone, rising and falling through greater and lesser distances, according to the secular and short period changes in the level of the ground-water, must greatly exaggerate the solvent power of soil-water over what it would be did these oscillations not exist" (p. 44).

Barometric changes, for example, exert a very marked and nearly, if not quite, immediate influence on the level of water in wells, especially those changes which take place suddenly, for the effects of long period barometric oscillations may be masked by other movements. A rise in the barometer is associated with a fall in well-water, and also with a diminution in the rate of flow of water from tile-drains, springs, and artesian wells, even from a well 979 feet deep. Semi-diurnal changes of level are also perceptible, a major minimum occurring from 7 to 10 a.m. and a minor one from 9 to 11 p.m., coinciding therefore in time with the maxima of the semi-diurnal barometric period. There appear to be two very different causes to which these movements may be attributed—(1) The general level of the ground-water may be depressed bodily by a rise of barometric pressure, and *vice versâ*, just as would be the case with the ocean surface with a change in the distribution of pressure. Or (2) when the barometer falls, the expansion of the air escaping from the water, and of that which exists in the interstitial soil-spaces above the ground-water, may force the capillary water out into the wells and drainage channels, the rarefaction of the soil-air allowing the return of the water into the passage-ways when the barometric conditions are reversed.

Changes in the temperature of the soil also produce changes in the level of the water-surface, the surface rising with an increase of temperature, and *vice versâ*; possibly in part from the expansion and contraction of the air which occupies the capillary spaces of the soil.

Heavily-laden railway-trains passing at a distance of 140 feet from one of the wells produced a rapid but gradual rise of the water of about $\frac{1}{10}$ of an inch, followed by a slightly less rapid fall again to the normal level. It is doubtful whether this is due to the compression of the earth by the weight of the train and consequent lateral displacement of the ground-water, or to the water being forced out of the capillary spaces just above the ground-water surface. The phenomena may, in any case, have some bearing on the movements of water in wells during earthquakes.

Lastly, these experiments have shown that the general impression that water cannot percolate through frozen soil is not quite correct. During three consecutive winters, at times of sudden thaws or winter rains, water has been observed to find its way through the frozen ground, probably by shrinkage cracks and worm burrows, into the drains and shallow wells of the experiment farm.

C. Davison.

VI.—Elementary Palæontology for Geological Students, by Henry Woods, B.A., F.G.S. Small 8vo. pp. vi. and 222, with 56 figures in the text. Cambridge Natural Science Manuals. Cambridge University Press. (October, 1893.)

ERROR is deathless; and an educational humorist once remarked that each new Text-book was a compilation of the mistakes of all its predecessors, with a few added on its own account. We

thought he was joking; but the truth probably is that he had just read a manual of Elementary Palæontology from the pen of Mr. H. Woods. The errors in this book may be divided into inherited and original. We select a few specimens from either class.

On page 2 it is stated that no remains of *Rhytina gigas* are found in the rocks. Reference to Dr. H. Woodward's paper (Quart. Journ. Geol. Soc. vol. xli. p. 457) would have shown that they are found nowhere else, while a glance at the labelled specimen in the British Museum would equally have shown the incorrectness of the statement, which we presume is original.

On page 12 *Nautilus* is said to extend from the Ordovician to the present day. This error, inherited from a dim antiquity, might have been avoided by looking at A. H. Foord's Catalogue of Fossil Cephalopoda in the British Museum (table on page xix.).

As for the geological ranges assigned in this manual to various genera of the Mollusca, it can only be said that the author's ideas of what should be included under those genera are too broad-minded to be of much scientific value. It is clear, for instance, that under *Cerithium* the whole of the true Cerithidæ are included, and, since there is no indication of the many sub-genera (or genera, as we should prefer to term them), the student hardly knows what meaning he should attach to statements about the genus. Indeed, in his molluscan nomenclature the author strangely ignores all the modern work on the subject.

On page 67 the remarks on the pedicellariæ of Asteroidea would have been better applied to those of Echinoidea, which are of a different character.

On page 85 errors bristle; *e.g.* "Cup" and "Calyx" are not interchangeable terms; "Disc" has never been used in the sense here applied to it; the arms of a Crinoid are hardly "soft parts"; pinnules are absent in a very large number of Palæozoic Crinoids; and so on.

On pages 88, 89 the exploded absurdity of a soft disc roofed over by a solid vault and the obsolete classification into Palæocrinoidea and Neocrinoidea are maintained, although Mr. Woods might have discovered the truth from the GEOLOGICAL MAGAZINE for May, 1891 (Dec. III. Vol. VIII. p. 220), or even from Nicholson and Lydekker's Manual of Palæontology (1889), which we notice that he has drawn upon in other instances. Why, out of the four genera chosen for description, three should be such aberrant forms as *Crotalocrinus*, *Apiocrinus* and *Marsupites*, we cannot imagine. This is originality with a vengeance.

Page 108.—This is a detail; but does a Cambridge man who knows the meaning of *dioeceous* (*sic*) really think that *umbone* is the singular of *umbones*?

To say, as is done on page 175, that the septal necks of Ammonoidea (except *Clymenia* and *Goniatites*) are directed forwards, is somewhat too broad a statement, whatever construction be put upon it; while the announcement that "in the Palæozoic the only genera [of Ammonoidea] are *Goniatites*, *Clymenia* and *Ammonites*" is, if not original, startlingly retrogressive. Originality must undoubtedly be

claimed for the "diagram-section" of *Belemnites*, page 179, which, in its peculiarly projecting collar, reminds one of a well-known political caricature.

We do not, of course, deny that, after eliminating these and similar slips, there remains a residuum of truth. The chapters on Foraminifera and Sponges, for instance, seem to have passed under a revising eye. But the method of residues, though useful enough to the chemical investigator, is of no great advantage to the student of palæontology. We should not have devoted so much space to pointing out the failings of the book, had we been able to discover anything in it that made up for them. One does not expect great things from an elementary manual; but *it must be correct.*

The list of works to which the student is directed will, however, enable him easily to rectify the errors of the manual itself. It would be ungracious to object to the inclusion of certain names in this list, since they at least give it a flavour of respectability; but we may be allowed to wonder why others have been omitted. Surely Mr. Woods does not wish to keep his students in ignorance of Malcolm Laurie's studies on the Eurypterida; and why is no mention made of the leading authorities on fossil Crinoids—P. H. Carpenter and Wachsmuth and Springer?

To conclude: for these 222 small pages of large type the University of Cambridge ask the student to pay six shillings. This will at least check the circulation of the book, a result that not even the author dare deplore. G. F. H., F. A. B.

VII.—*Ueber Æpyornis.* By R. Burckhardt. Palæontologische Abhandlungen. Neue Folge. Band II. Heft 2. (Jena, 1893.)

IN this memoir the author gives an account of some remains of *Æpyornis* collected by Hildebrandt near Sirabé, in Central Madagascar, during the year 1880, and now deposited in the Mineralogische Museum in Berlin.

The special interest of the paper lies in the fact that in it we have, for the first time, a description and figures of the pelvis, an immature metatarsus, and a complete fully adult specimen of the same bone, of which the proximal end was previously unknown. The collection also includes a complete tibia, an imperfect femur, some vertebræ and fragments of ribs. The author considers that these bones belong to a new species (*Æ. Hildebrandti*), intermediate in size between the *Æ. medius* and *Æ. modestus* of Milne-Edwards.

The pelvis, the most important of the specimens described, possesses the following characters: (1) The whole of the constituent bones unite without trace of suture. (2) The post-sacral vertebræ are much reduced in size. (3) The bulk of the pelvis lies in front of the acetabulum. (4) The axis of the pelvic vertebræ at first runs straight back, then, from vertebræ 7–12, opposite the acetabulum it forms a strong ventral convexity, behind which the reduced post-sacral vertebræ slope away dorsalwards. (5) There is a pre-acetabular process. (6) The ischium, which is convex outwards,

consists of a thickened central axis with dorsal and ventral wings. The post-sacral connection is ligamentous.

The proximal articular surface of the metatarsus has no inter-condylar process, but instead there is a shallow median groove which receives a ridge on the distal end of the tibio-tarsus, between the condyles. In the immature metatarsus, the fourth metatarsal is more weakly developed than the others, at least at the upper end.

After an exhaustive comparison of the osteological characters of *Æpyornis* with those of the other Ratites, the author comes to the conclusion that the Æpyornithidæ constitute a distinct family, having no near relations, and being highly specialized and characterized by the massive structure of the skeleton accompanied by the pneumaticity of some of its parts. The resemblances with the Dinornithidæ he regards as superficial and merely the result of convergence due to similar conditions of life; on the other hand, the differences are considered to be of great importance, *e.g.* the pneumaticity of the femur, which, among the Ratitæ, occurs in *Æpyornis* and *Struthio* alone. *Struthio* also resembles *Æpyornis* in some other respects, *e.g.* the structure of the egg-shell, so that on the whole the relationship between them is regarded as less remote than that existing between the Æpyornithidæ and the other Ratite families. In conclusion, it is suggested that the Dromaeidæ and Casuaridæ, which, especially the former, are, in some respects, the least specialized Ratites, may be the recent representatives of a parent stock, from which, on the east, arose the Dinornithidæ and Apteryx; while, on the west, the ancestors of *Struthio* and *Æpyornis* branched off, the former making their way into Africa through India and Arabia, the latter reaching Madagascar by way of Southern India.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 8th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "The Geology of Bathurst, New South Wales." By W. J. Clunies Ross, Esq., B.Sc., F.G.S.

After sketching the physiography of the Bathurst district, the author describes in detail its stratigraphy. The oldest sedimentary rocks are Silurian, but the floor on which they rest is unknown, and the author states that it was probably fused up and incorporated in the granite which is described in the paper. The Silurian rocks may have been folded before the granite was erupted; in any case the granite produced a zone of contact-metamorphism, whilst almost all the Silurian rocks may be considered to be examples of regional metamorphism, though the agents producing the metamorphism were least active to the east of Bathurst, where the Silurian limestones are very little altered. An anticlinal was probably produced at the time of the granitic intrusion. After a time there was subsidence, but at first it need not have been very extensive, since

the Devonian conglomerates, sandstones, and shelly limestones were probably deposited in a comparatively shallow sea. They contain *Lepidodendron australe.* At Rydal they abut against the uplifted Silurian rocks of the Bathurst area. At the end of Devonian times there appears to have been a long interval, during which both Silurian and Devonian rocks were greatly denuded, and the granite exposed in places. The Upper Carboniferous and Permian rocks were deposited in the Lithgow district, but it is doubtful if they ever extended to Bathurst. There is nothing to show what happened in this region during Mesozoic and early Tertiary times. The Hawkesbury Sandstone (probably Triassic) may have approached nearer to Bathurst than it does now. In late Tertiary times stream-deposits were formed on the granitic rocks, and afterwards covered with thick basaltic lava-flows, which have since undergone much denudation.

2. "The Geology of Matto Grosso (particularly of the region drained by the Upper Paraguay)." By J. W. Evans, D.Sc., LL.B., F.G.S.

The district includes a portion of the Brazilian hill-country, and also of the low-lying plains to the south-west.

The rocks principally dealt with are unfossiliferous, and of unknown age, except that they appear to be older than the Devonian. They may be classified as follows:—

5. Matto Shales. (Relations not shown.)
4. Rizama Sandstone. (Perhaps some unconformity.)
3. Curumbá and Arara Limestones. (Very marked unconformity.)
2. Cuyabá Slates. (Strong unconformity.)
1. Ancient crystalline rocks.

The Devonian and later rocks are briefly described.

3. "Notes on the Occurrence of Mammoth-remains in the Yukon District of Canada and in Alaska." By George M. Dawson, C.M.G., LL.D., F.R.S., F.G.S.

In this paper various recorded occurrences of Mammoth-remains are noted and discussed. The remains are abundant in, if not strictly confined to, the limits of a great unglaciated area in the north-western part of the North American continent; whilst within the area which was covered by the great ice-mass which the author has described as the Cordilleran glacier, remains of the Mammoth are either entirely wanting or are very scarce. At the time of the existence of the Mammoth, the North American and Asiatic land was continuous; for an elevation of the land sufficient to enable the Mammoth to reach those islands of the Behring Sea where these bones have been found would result in the obliteration of Behring Straits.

The bones occur, along the northern coast of Alaska, in a layer of clay resting on the somewhat impure "ground-ice formation," which gives indications of stratification; and above the clay is a peaty layer. The author considers this "ground-ice" was formed as a deposit when more continental conditions prevailed, by snow-fall on a region without the slopes necessary to produce moving

glaciers. The Mammoth may be supposed to have passed between Asia and America at this time. At a later date, when Behring Straits were opened and the perennial accumulation of snow ceased on the lowlands, the clay was probably carried down from the highlands and deposited during the overflow of rivers. Over this land the Mammoth roamed, and wherever local areas of decay of ice arose, bogs would be produced which served as veritable sink-traps. The author considers it probable that the accumulation of "ground-ice" was coincident with the second (and latest) epoch of maximum glaciation, which was followed by an important subsidence in British Columbia.

CORRESPONDENCE.

THE RECENT GEOLOGICAL HISTORY OF THE ARCTIC LANDS.

In Sir Henry Howorth's article, bearing the above title, which appeared in the November Number of this MAGAZINE, he writes (at page 499), "so far as we can make out, the climate (of the Circumpolar Lands) has been becoming more and more severe in historic times, and that in the Pleistocene age, so far as we have evidence, the climate of the Polar area was more, and not less, temperate than now." . . . . . "This again is confirmed by such facts as the occurrence of the great sea-cows, which Steller discovered around Behring's Island, in a latitude far away from all their relatives and congeners. They are essentially animals which thrive under temperate or subtropical conditions, and this colony, so lately occurring in the North Pacific, seems to point clearly to the climate of that region having been recently milder."

Quoting from my paper on Fossil *Sirenia* (GEOL. MAG. 1885, p. 423), "Assuming, as I think we may, that the living *Sirenia belong exclusively to the tropical regions of the earth,* and that *Rhytina,* in its boreal home, was simply a surviving relic from the past, a sort of geological 'outlier,' we must conclude that the presence of about 12 genera and 27 species of fossil *Sirenia,* as widely distributed (over Europe and America) then, as the recent forms are (within the tropics) at the present day, *but with a range from the tropic of Cancer up to (nearly) 60° of north latitude,* attests the former northern extension of subtropical conditions of climate which must have prevailed over Europe, Asia, and North America in Tertiary times."

It seems to me that the only doubtful point is as to when and how long in Tertiary times this warmer condition of climate lasted. Nor must we omit to bear in mind that the survival of "Steller's sea-cow" (*Rhytina gigas*), down to 1780, around the shores of Behring and Copper Islands, in 55°–60° N. latitude, is very largely, if not wholly, due to the "Kuro-Sivo," or "Black River," *the Gulf-stream* of the Northern Pacific, which, by its warm waters, encourages the growth so far to the northward of those vast submarine meadows of succulent Algæ on which these Phytophagous Sirenians subsisted. Nor has the changing climate or want of food caused the elimination

of this last survivor of Tertiary times, but the hand of Man the destroyer. The wide distribution of numerous species of *Sirenia* in Tertiary times over Europe and America is, however, a powerful argument in favour of the former higher temperature of our Northern hemisphere.

HENRY WOODWARD.

THE CARBON-CRUST ON FOSSIL PLANTS.

SIR,—It is well known that Fossil plants when found in sandstone are generally entirely covered with a thin layer of nearly pure carbon; in the case of Calamites, etc., in the Coal-measure sandstones the layer is often not more than about $\frac{1}{20}$ of an inch in thickness. It very readily falls away, and it is only in rare cases that it adheres to the sandstone cast. I should like to propose some questions concerning this carbonaceous covering to your readers. (1) Why is the whole of the carbonaceous residue in well-preserved fossils confined to the outside of the cast? (2) Does the carbonaceous layer represent the whole of the carbon of the tissue of the plant? (3) Why, in comparatively soft and little altered freestones, should the carbonaceous layer exhibit such a baked or charred appearance?

A. WILMORE.

WESLEYAN SCHOOLS, TRAWTEN, COLNE, LANCASHIRE,
November 8th, 1893.

OBITUARY.

JOHN HOOKE TAUNTON, M.INST.C.E., F.G.S.

EARLY in the present year[1] we lost by death Mr. John Hooke Taunton, M.Inst.C.E., F.G.S., of Stroud. Mr. Taunton had an intimate acquaintance with the water-bearing strata of the Cotteswold Hills, and furnished some valuable information to the Report of the Commissioners on Water Supply (1869). He was for many years local engineer to the Thames and Severn Canal Company, and also consulting engineer to the Stroud Local Board of Health. He contributed several papers to the Proceedings of the Cotteswold Naturalists' Club, of which he was an active member: among these were papers on the Hydrology of the Cotteswolds, on the Geology of the Sapperton Tunnel, on the Malmesbury Waterworks, and on the Dynamic Geology of Palestine.

THE REV. H. W. CROSSKEY, LL.D., F.G.S.

BORN 1826. DIED OCTOBER 1ST, 1893.

IN Dr. H. W. Crosskey we have to record the loss of one who was a most ardent student of Glacial Geology and the author of a valuable series of Reports on the Erratic blocks of this country, communicated during the past 20 years to the British Association. He paid much attention to the post-Tertiary deposits of the Clyde Valley, and was associated with David Robertson and Dr. G. S. Brady in describing the post-Tertiary Entomostraca in the Palæontographical Society's Volume for 1874. Whilst resident in Glasgow he contributed many papers to the Geological Society of Glasgow. He died at his residence, Edgbaston, Birmingham, Oct. 1st, 1893.

[1] January 31st, 1893.

INDEX.

ABB

ABBOTT, G., Was the Deposit of Flint and Chalk Contemporaneous? 275; The Relative Age of Flints, 477.
Abnormal Forms of *Spirifera lineata*, 249.
Abstracts of Papers read at British Association (Geology), 548.
Æpyornis, Upon, 572.
Affinities of *Anthracoptera* and of *Anthracomya*, 188.
——— ——— the Genus *Astrocœnia*, 378.
Africa, Contributions to the Geology of, 436.
——— Geological Sketch of Central East, 561.
Alps, On some Quartz-schists from the, 204.
American Tapir, Evolution of the, 391.
Analysis of the Fuller's Earth of Vrongoch, 160.
Anchisaurus, *Ceratosaurus*, and *Claosaurus*, 150.
Annals of British Geology, 134.
Annual General Meeting of the Geological Society, 180.
Anomœodus, On the Genus, 487.
——— *superbus*, A. S. Woodw., sp. nov., 489.
——— *Willetti*, A. S. Woodw., sp. nov., 489.
Antarctic Continent, The, 225.
Anthracite and Bituminous Coal-beds, 136.
Anthracoptera Fossil, 540.
Aptychopsis Williamsii, T. R. J. and H. W., sp. nov., 201.
Arabia Petræa, The Geological Features of, 44.
Archipelago, Note on the Tuscan, 272.
Arctic Lands, 495.
——— Recent Geological History of the, 575.
——— in the so-called Glacial Age, 302.
Armstrong, James, Obituary of, 94.
Arnold-Bemrose, H. H., on the Derbyshire Toadstone, 559.
Astrocœnia gibbosa, Tomes, from New South Wales, 379.
Athrodon crassus, A. S. Woodw., sp. nov., 435.

BOU

Athrodon intermedius, A. S. Woodw., sp. nov., 434.
——— *tenuis*, A. S. Woodw., sp. nov., 435.
Aveline, W. T., The St. Bees Sandstone, 87.

BACUP, New Species of *Cyclus* from, 28.
Bajocian of the Sherborne District, 375.
Ball, V., on the Volcanoes of Barren Island, 289.
Barren Island and Narcondam, Volcanoes of, 289.
Barrow, G., on Thermo-metamorphism, 238.
Bathurst, The Geology of, 573.
Bayfield, T. G., Obituary of, 240.
Bell, Dugald, Origin of certain Granite Boulders in the Clyde Valley, 138; Alleged Submergence of Britain during the Glacial Epoch, 333.
Bendigo Gold-field, 565.
Berthelot's Principle applied to Magmatic Concentration, 546.
Bertrand, M., The Mountains of Scotland, 118.
Biotite in the Crystalline Schists from the Binnenthal, 47.
Blake, J. F., Annals of British Geology, 134; The Shell-beds of Moel-Tryfaen, 267; on the Felsites and Conglomerates between Bethesda and Llanllyfni, 287.
Blanford, H. F., Obituary of, 190.
Bolivia, Palæozoic, Fossils from, 367.
Bolton, H., on the Occurrence of a Trilobite in the Skiddaw Slates, 29.
Bonney, T. G., Note on the Nufenenstock, 46; Greenstones and allied Hornblendic Schists from the Pennine Alps, 46; Biotite and Hornblende in Crystalline Schists from the Binnenthal, 47; on some Quartz Schists from the Alps, 204.
——— and Raisin, on the so-called Spilites of Jersey, 59: on the Variolite of the Lleyn, 86.
Boring at Willoughby, in Lincolnshire, 142.
Borings in East Lincolnshire, 329.
Boulders and Pebbles from the Glacial Drift, 189.

Brachiopoda of Minnesota, 421.
——— —— New Classifications of, 318.
Brehm, A. E., Marvels of Nature, 178.
Bridgewater District, Ontario, 47.
British Association for the Advancement of Science, 469, 548.
——— Earthquakes, 291.
——— British Geology, Annals of, 134.
——— Iron-ores, 372.
Brodie, P. B., Fish-remains in Green Marls of Warwickshire, 84; Eocene Tertiary Insects of the Isle of Wight, 538.
Bryozoa from the Inferior Oolite of Shipton Gorge, 285.
Buckman, S. S., Titles of Separate Copies of Scientific Papers, 140; The Bajocian of the Sherborne District, 375.
Burckhardt, R., on *Æpyornis*, 572.

CALAMITES, Notes on some Pennsylvanian, 85.
Calamostachys Binneyana, Schimp., 85.
Callaway, C., Origin of the Crystalline Schists, 286; Conversion of Chlorite into Biotite, 535.
Cambridge, Jurassic Rocks near, 40.
——— University, 48.
Cambrian in Wales, Base of the, 548.
Canada, Devonian Fishes of, 145, 262.
Candona subreniformis, T. R. Jones, sp. nov., 388.
——— *subovata*, T. R. Jones, sp. nov., 388.
Carbon-crust on Fossil Plants, 576.
Carboniferous Fossils of New South Wales, 80.
Carnivorous Dinosaur, from Peterborough, 238.
Catalogue of British Jurassic Gasteropoda, 38.
Cause of Crateriform Sand Dunes and Cwms, 323.
Cavern Researches, 327.
Cephalaspis Jexi, Traquair, sp. nov., 147.
Cestraciont Remains from the Green Marls, Warwickshire, 84.
Chapman, F., on Sheared Limestones from Ilfracombe, 100.
——— and Sherborn, on the Ostracoda of the Gault at Folkestone, 345.
Charlesworth, Edward, Obituary of, 526.
Charms, Fossils applied as, 246.
Cheilostomatous Bryozoa from the Middle Lias, 379.
? *Cheiracanthus costellatus*, Traquair, sp. nov., 146.
Choffat, P., on the Jurassic Fauna of Portugal, 371.
Claims of Priority, 288.
Clarke and Hall, Study of Palæozoic Brachiopoda, 134, 518.
Claypole, E. W., The Upper Devonian Fishes of Ohio, 443.
Clyde Valley, Granite Boulders in the, 138.
Conrad's Fossil shells of North America, 564.
Coal-measures, a new Palæoniscid Fish from the, 54.
——— —— Fossil Fish-remains of the, 72.
Cœlodus fimbriatus, A. S. Woodw., sp. nov., 491.
——— *inæquidens*, A. S. Woodw., sp. nov., 491.
Cole, G. A. J., Rocks of the Volcano of Rhobell Fawr, 337.
Collins, J. H., Geological Notes on the Bridgewater District of Ontario, 47.
Concealed Ridge of pre-Carboniferous Rocks at Netherseal, 552.
Concentric Lamination amongst Pebbles on Northam Ridge, 477, 526.
Conflict between Geology and Physics, 87
Contemporaneity of Chalk and Flint, 275.
Cooke, J. H., The Marls and Clays of the Maltese Islands, 45; *Ursus ferox* in the Pleistocene of Malta, 67; Maltese Cave Exploration, 144; Concretionary Masses of Flint and Chert in Maltese Limestones, 157.
Coryphodon, Restoration of, 481.
Cossmann, M., Revision of the Oligocene Fauna of Etampes, 424.
Crane, Agnes, New Classification of the Brachiopoda, 318.
Cranial Osteology of *Lepidotus* and *Dapedius*, 413.
Cretaceous Pycnodont Fishes, 433, 487.
Crosskey, Rev. H. W., Obituary of, 576.
Crustacea, A History of, 324.
Cybium Bleekeri, On a Cranium of, 326.
Cyclus, from the Coal-measures, 28.
——— *Scotti*, H. Woodw., sp. nov., 28.
——— *Woodwardi*, Reed, sp. nov. ? 65.
Cythere lineatopunctata, Chap. and Sherb., sp. nov., 348.
——— *monticula*, T. R. J., sp. nov., 389.
——— ? *spinifera*, Chap. and Sherb., sp. nov., 348.
Cythereis excavata, Chap. and Sherb., sp. nov., 348.
——— *rudispinata*, Chap. and Sherb., sp. nov., 348.
——— *triplica*, Chap. and Sherb., sp. nov., 348.

CYT

Cytheridea rotundata, Chap. and Sherb., sp. nov., 349.
——— *tenuis*, T. R. J., sp. nov., 390.
——— *truncata*, T. R. J., sp. nov., 390.
Cytherideis æqualis, T. R. J., sp. nov., 390.
——— *impressa*, T. R. J., sp. nov., 391.
Cytheropteron Folkestoniensis, Chap. and Sherb., sp. nov., 349.

DARTMOOR, Notes on, 329.
Davies, Thomas, Obituary of, 69.
Davis, James William, Fossil Fish-remains of the Coal-measures, 72.
——— Obituary of, 427.
Davison, C., on the British Earthquakes of 1892, 291; Note on the Quetta Earthquake, 356; on the Growth of Lake Geneva, 454.
Dawson, G. M., Occurrence of Mammoth-remains in the Yukon district of Canada, 574.
Deeley, R. M., on the Glacial Succession, 31.
Dentition of *Myliobatis* from the Tertiary of Egypt, 414.
Derbyshire Toadstone, 559.
Devonian Fishes of Campbelltown and Scaumenac Bay, 145, 262.
——— Rocks, Folds and Faults, in the, 3.
Dinosaurian Teeth from Aylesbury, 378.
——— ——— Vertebra from the Wealden of Hastings, 84.
Discites from the Lower Carboniferous of Ireland, 251.
——— *Hibernicus*, Ford and Crick, sp. nov., 253.
Disseminated Silica in Chalk considered in Relation to Flints, 541.
Dunlop, A., on Raised Beaches at a High Level in Jersey, 375.
Dunn's Bendigo Gold-field, 565.
Dwindling and Disappearance of Limestones, 285.
Dykes of Arran, 376.
———Hope, Idaho, The Study of the, 379.

EARLE, C., The Evolution of the American Tapir, 391
Earthquake, Note on the Quetta, 356.
Earthquakes, On British, 291.
Elgin Sandstones, New Reptiles from the, 173.
Eminent Living Geologists, 1, 241.
Emmons, H., on the Petrography of the Island of Capraja, 86.
Engadine Lakes, On the Origin of the, 448.
Eocene Tertiary Insects of the Isle of Wight, 538.

FUL

Eskdale Drift, 9.
Estheria striata, var. *Muensteriana*, T. R. J., nov., 530.
——— *Reinachii*, T. R. J., sp. nov., 531.
——— *Geinitzii*, T. R. J., sp. nov., 531.
——— ——— var. *Grebeana*, T. R. J., nov., 532.
Etampes, Marine Oligocene Fauna of, 424.
Etheridge, R., Jun., Monograph of Carboniferous Invertebrata, 80.
Evans, J. W., The Geology of Matto Grosso, 574.
Excursions around Bath, 330.
Extinct Monsters, 41.

FELSITES and Conglomerates in North Wales, 289.
Fisher, O., on the Thickness of Marine Deposits, 255.
Fishes of Ohio, The Upper Devonian, 443.
Fish-remains from the Coal-measures of Britain, 72.
Flint and Chalk, 275.
——— Chert in Maltese Limestone, 157.
—— The Relative Age of, 315, 477.
Flints, Silica in Chalk considered in Relation to, 541.
Florida, Contributions to the Tertiary Flora of, 472.
Folds and Faults in Devonian Rocks, 3.
Folkestone, On the Ostracoda of the Gault at, 345.
Foord, A. H., Claims of Priority, 288.
——— and Crick, on a New Species of *Discites* from Ireland, 251.
Foraminiferal Limestone from the Grenadine Islands, 270.
Forbes, H. O., The Chatham Islands and their Relation to an Antarctic Continent, 225.
Fossils applied as Charms or Ornaments, 246.
Fossil *Phyllopoda* of the Palæozoic Rocks, 529.
Fossil-remains from Samos, 69.
—— Reptilia, Classification of the, 360.
—— Sponges, 524.
Fox, Howard, Notes on Coast Sections at the Lizard, 136; on a Radiolarian Chert from Mullion Island, 137; Radiolarian Cherts of Cornwall, 558.
Fox-Strangways, E., on the Jurassic Rocks of Britain, 415.
Fraas, E., on the Irpfel Cavern, 327.
Frederick, G. C., Geological Remarks on the New Hebrides, 189.
Fritsch, Anton, Fauna of Gas-coal, 175.
Fuller's Earth of Vrongoch, Analysis of, 160.

GAS

GAS-COAL, Fauna of the, 175.
Gasteropoda, British Jurassic, 38.
Geological Development of the Mammalia, 401, 455, 501.
——— History of Arctic Lands, 495.
——— Remarks on certain Islands in the New Hebrides, 189.
——— Society of Glasgow, 138, 333.
——— ——— London, 44, 84, 135, 180, 238, 284, 328, 375, 573.
——— Survey, 415.
——— ——— of United States, 523.
——— Time, Measurement of, 97.
Geologists' Association, 330.
Geologists, Eminent Living, 1, 241.
Geology of Africa, 436.
——— of the District West of Caermarthen, 138.
——— of the Southern Transvaal, 521.
——— and Palæontology of South America, 367.
——— and Palæontology of Queensland, 279.
——— Text Book of Comparative, 361.
Gibson, Walcot, Geological Sketch of Central East Africa, 561.
Glacial Action in Iceland, 426.
——— Age, Arctic Lands in the so-called, 302.
——— Geology, 93.
——— ——— and Eskdale Drift, 9.
——— ——— Old and New, 35.
——— Submergence of the British Islands, 277.
——— Succession, 31.
——— Period, Submergence of the British Isles during the, 104.
Glacier Observations, 349.
Gosselet, M., Phosphate Beds in the North of France, 563.
Granite, 41.
"Greenstones" from the Pennine Alps, 46.
Grenadine Islands, Foraminiferal Limestone from the, 270.
Gresley, W. S., Notes on some Pennsylvanian Calamites, 85; Anthracite and Bituminous Coal-beds, 136.
Growth of the Indian Peninsula, 309.
——— Lake Geneva, Notes on the, 454.

HALL and Clarke, Introduction to the Study of Palæozoic Brachiopods, 130; on Palæozic Brachiopods, 518.
——— ——— Marshall, Glacier Observations, 349.
Hardy, J. D., on Glacial Submergence, 277.

HUN

Harker, Alfred, Scandinavian Rocks in the English Boulder-clays, 140; Metamorphic Rocks around the Shap Granite, 287; Magmatic Concentration, 546.
Harlé, E., on Cavern and Pleistocene Deposits, South of France, 327.
Harris, G. D., Republication of Conrad's Fossil Shells of North America, 564.
Hicks, Henry, Folds and Faults in the Devonian Rocks, 3; The Mammoth and the Glacial Drift, 90, 139; The Pre-Cambrian Rocks of Wales, 396; on the Base of the Cambrian in Wales, 548.
—— T., on *Calamostachys Binneyana*, Schimp, 85.
Higgins, Rev. H. H., Obituary of, 380.
Hind, Wheelton, on the Affinities of *Anthracoptera* and of *Anthracomya*, 188; Note on *Myalina crassa*, 514; Slab of Shale above the Kinder Scout Grit, 540.
Hinde, G. J., on a new Hexactinellid Sponge from Quebec, 56; Note on a Radiolarian Rock from Port Darwin, 137.
Hobson, Bernard, Granite, 91.
Holm, Gerhard, on the Hyolithidæ and Conulariidæ of Sweden, 368.
Homfray, David, Obituary of, 479.
Hornblende-Pikrite from Wicklow, 550.
Howell, F. W. W., Glacial Action in Iceland, 426.
Howorth, Sir H. H., The True Horizon of the Mammoth, 20, 161, 355; The Mammoth and the Glacial Drift, 89; Condition of the Arctic Lands in the so-called Glacial Age, 302; Recent Geological History of Arctic Lands, 495.
How the Waters of the Ocean became Salt, 165.
Hudleston, W. H., Catalogue of Jurassic Gasteropoda, 38.
Hull, E., on the Geological Features of Arabia, Petræa, and Palestine, 44; Submergence of the British Isles during the Glacial Period, 104; How the Waters of the Ocean became Salt, 165; Discovery of a Concealed Ridge of Pre-Carboniferous Rocks at Netherseal, 552; The Water-bearing Capacity of the New Red at Nottingham, 553.
Hunt, A. R., The Rocks of South Devon, 139; The Pebble-ridge at Westward Ho, 477; Concentric Lamination amongst the Pebbles on Northam Ridge, 526.

HUT

Hutchinson, H. N., Extinct Monsters, 41.
Hutton, F. W., on a New Plesiosaur from New Zealand, 378.
Hyolithes and *Conularia*, 368.

IDDINGS, J. P., on the Volcanoes of Wyoming, 559.
Igneous Rocks at Barnavave, Carlingford, 551.
Indian Peninsula, The Growth of the, 309.
Intrusive Sheets of Diabase near Bassenthwaite, 378.
Ireland, New Species of *Discites* from, 251.
Iron-ore in the Lias of Raasay, 492.
Irving, A., Keuper Formation of Devon, 44; Selenology, 48; post-Eocene Surface-changes in London Basin, 211.
Isle of Wight, Eocene Tertiary Insects of the, 538.

JACK and Etheridge, Geology of Queensland and New Guinea, 279.
Japan, Seismological Society of, 515.
Jersey, On the so-called Spilites of, 59.
Jervis, Chev. W. P., Volcano of Mergellina, 235.
Jones, Prof. T. R., Biographical Notice of, 1; on Some Palæozoic Ostracoda from Westmoreland, 248; on Some Palæozoic Ostracoda from Girvan, 285; on Some Fossil Ostracoda from Wyoming and Utah, 385.
——— and Woodward, on Palæozoic Phyllopods, etc., 198; The Fossil *Phyllopoda* of the Palæozoic Rocks, 529.
Judd, J. W., Tertiary Granite in the Gabbro of the Cuilin Hills, 135; on Composite Dykes in Arran, 376.
Jukes-Browne, A. J., The Mammoth of the Glacial Drift, 141; A Boring at Willoughby in Lincolnshire, 142, 329; Foraminiferal Limestone from the Grenadine Islands, 270; The Relative Age of Flints, 315; Disseminated Silica in Chalk considered in Relation to Flints, 541.
Jurassic Fauna of Portugal, 371.
——— Rocks, near Cambridge, 40.
——— ——— of Britain, 415.

KAYSER, E., Text Book of Comparative Geology, 361.
Kendall, J. D., Iron-ores of Great Britain and Ireland, 372.

MAR

Keuper Formation in Devon, 44.
Kinder Scout Grit, Slab of Shale from above the, 540.
King, F. H., Fluctuations of Level of Groundwater in Wisconsin, 568.

LAKE, Philip, The Growth of the Indian Peninsula, 309; Llandovery and Associated Rocks near Corwen, 328.
Lake Geneva, Note on the Growth of, 454.
——— Tanganyika, The Rise and Fall of, 379.
Lakes of Zurich and Wallen, 222.
Lemuroid Mammals from Madagascar, 336.
Lepontine Alps, 46.
Lincolnshire, A Remarkable Spring in, 96.
Lizard, Coast-Sections at the, 136.
London Basin, post-Eocene Surface-changes in the, 211.
Lydekker, R., on a Suropodous Dinosaurian Vertebra from Hastings, 48; Jaw of a Carnivorous Dinosaur from Peterborough, 238; Mammalian Incisor from Hastings, 238; Dinosaurian Teeth from Aylesbury, 378.

MADAGASCAR, Discovery of a Secondary Reptile in, 194.
Madsen, Victor, Scandinavian Boulders at Cromer, 85.
Magmatic Concentrations, Berthelot's Principle applied to, 546.
Major, C. J. Forsyth, on the Fossil-remains from Samos, 69; on *Megaladapis madagascariensis*, 336.
Maltese Cave-exploration, 144.
——— Islands, Marls and Clays of, 45.
——— Limestones, Flint and Chert in, 157.
Malvern Crystallines, 92.
Mammalia, Geological Development of the, 401, 455, 501.
Mammalian Incisor from the Wealden of Hastings, 238.
Mammoth and the Glacial Drift, 89, 90, 139, 141.
——— Remains in the Yukon District of Canada and in Alaska, 574.
——— The True Horizon of the, 20, 107, 161, 334, 353.
Marine Deposits, On the Thickness and Expansion of, 255.

MAR

Marsh, O. C., Restoration of Dinosaurs (*Anchisaurus*, *Ceratosaurus*, and *Claosaurus*), 150; Restoration of *Mastodon Americanus*, Cuvier, 164; Restoration of *Coryphodon*, 481.
Marvels of Nature, 178.
Mastodon Americanus, Restoration of, 164.
Matto Grosso, The Geology of, 574.
McMahon, C. A., Notes on Dartmoor, 329.
Measurement of Geological Time, 97.
Mergellina, Submerged Volcano of, 235.
Mesozoic Ganoid Fishes, 413.
Metacypris consobrina, T. R. Jones, sp. nov., 388.
——— *cuneiformis*, T. R. Jones, sp. nov., 389.
——— *simplex*, T. R. Jones, sp. nov., 389.
——— *subcordata*, T. R. Jones, sp. nov., 388.
Metamorphic Rocks around the Shap Granite, 287.
Meteoric Stone found at Makariwa, 130.
Microscopic Structure of the Wenlock Limestone, 188.
Minnesota, Geological Survey, 421.
Moel Tryfaen, The Shell-beds of, 267.
Molluscan Remains lately discovered in the English Keuper, 557.
Monckton, H. W., Boulders and Pebbles from the Glacial Drift, 189.
Monograptus priodon, Skeleton of, 551.
Monsters, Extinct, 41.
Mountains of Scotland, 118.
Murchison Gold Field of Western Australia, 288, 412.
Muscovite-biotite-gneiss in the Southern Highlands, 238.
Myalina crassa, Note on, 514.
Myliobatis, on the Dentition of an Extinct Species of, 414.
Myriolepis Hibernicus, Traquair, sp. nov., 54.

NEWBERRY, Prof. J. S., Obituary of, 94.
New Guinea, Geology and Palæontology of, 279.
—— York, Palæontology of, 518.
—— South Wales, Carboniferous Fossils of, 80.
Newton, E. T., New Reptiles from the Elgin Sandstone, 173; Reptilia of the British Trias, 555.
——— R. B., a Secondary Reptile from Madagascar, 194; Molluscan Remains lately discovered in the English Keuper, 557.
Novák, Dr. Ottomar, Obituary of, 190.

PLA

OBITUARY of Professor Sir Richard Owen, 48, 49; James Armstrong, 94; Prof. J. S. Newberry, 94; Thomas Davies, 96; Prof. J. O. Westwood, 143; Martin Simpson, 144; Dr. Ottomar Novák, 190; Henry Francis Blanford, 191; Thomas Gabriel Bayfield, 240; Rev. H. H. Higgins, 380; James William Davis, 427; David Homfray, 479; G. W. Shrubsole, 480; Edward Charlesworth, 526; J. H. Taunton, 576; Rev. H. W. Crosskey, 576.

Ohio, The Upper Devonian Fishes of, 443.
Old and New Glacial Geology, 35.
Oligocene Fauna of Etampes, 424.
Oolitic Limestones with Sheared Structure from Ilfracombe, 100.
Origin of Crystalline Schists, 286.
——— the Engadine Lakes, 448.
Ostracoda of the Gault at Folkestone, 345.
——— from S.W. Wyoming, 385.
Owen, Prof. Sir Richard, Obituary of, 48, 49.

PALÆONISCID Fish from Kilkenny, 54.
Palæontology, Elementary, 570.
Palæontology of New York, 518.
Palæosaceus, Hinde, gen. nov., 57.
——— *Dawsoni*, Hinde, sp. nov., 58.
Palæospondylus Gunni, A Further Description of, 471.
Palæospongiologie by Dr. Hermann Rauff, 524.
Palæozoic Brachiopoda, 130.
——— Ostracoda from Westmoreland, 284.
——— ——— from Girvan, 285.
——— Phyllopods and other Fossils, 198.
Palæozoic Rocks, the Fossil *Phyllopoda* of the, 529.
Pebble-Ridge at Westward Ho, 477.
Peltocaris Salteriana, T. R. Jones and H. Woodw., sp. nov., 199.
Penning, W. H., Geology of the Southern Transvaal, 521.
Perlitic Quartz Grains in Rhyolite, 550.
Permian Fauna of Bohemia, 175.
Petrography of the Island of Capraja, 86.
Petrography, 565.
Philippi, R. A., on the Fossil Bones of Ulloma, 328.
Phosphate Beds in the North of France, 563.
Plateau-gravels South of Reading, 190.

PLE

Pleistocene of Malta, Occurrence of *Ursus ferox* in the, 66.
Post-Eocene Surface Changes in the London Basin, 211.
Postlethwaite, J., on an Intrusive Sheet of Diabase near Bassenthwaite, 378.
Post-Tertiary Vertebrate Remains from Madagascar, 194.
Potamocypris affinis, T. R. Jones, sp. nov., 387.
Pre-Cambrian Rocks of Wales, 396.
Preller, C. S. Du Riche, Note on the Lakes of Zurich and Wallen, 222; Notes on the Tuscan Archipelago, 272; On the Origin of the Engadine Lakes, 448.
Preston, S. T., Conflict between Geology and Physics, 87.
Prestwich, Prof. J., Biographical Notice of, 241.
Pycnodont Skull, On the Structure of the, 487.

QUARTZ-SCHISTS from the Alps, 204.
Quaternary and ? Tertiary Deposits in Texas, 92.
Quebec Group, New Hexactinellid Sponge from the, 56.
Quetta Earthquake, The, 356.

RAASAY, Iron-ore in the Lias of, 493.
Radiolarian Chert from Mullion Island, 137.
——— of Cornwall, 558.
——— Rocks from Fanny Bay, 137.
Railway Danger, An Unfamiliar, 380.
Raised Beaches of Jersey, 375.
Raisin, Miss C. A., Contributions to the Geology of Africa, 436.
——— and Bonney, on the so-called Spilites of Jersey, 59; on the Variolite of the Lleyn, 86.
Rauff, H., on Fossil Sponges, 524.
Reade, T. M., on the Eskdale Drift, 9; Glacial Geology, 35; Measurement of Geological Time, 98.
Reed, F. R. Cowper, Woodwardian Museum Notes, 64, 249.
Relative Age of Flints, 315.
Restoration of *Coryphodon*, 481.
——— of Dinosaurs, *Anchisaurus*, of *Ceratosaurus* and *Claosaurus*, 150.
——— of *Mastodon Americanus*, Cuvier, 164.
Reptiles from the Elgin Sandstone, 173.
Roberts, T., Jurassic Rocks in the Neighbourhood of Cambridge, 40;

STE

Geology of the District West of Caermarthen, 138.
Rock Metamorphism, 535.
Rocks in the Neighbourhood of Corwen, 328.
——— of South Devon, 139.
——— of the Volcano of Rhobell Fawr, 337.
Ross, W. J. C., The Geology of Bathurst, 573.
Rutley, F., Dwindling and Disappearance of Limestones, 285.

SALT, How the waters of the Ocean became, 165.
Samos, On the Fossil-remains from, 69.
Sand-Dunes and Cwms, Cause of Crateriform, 323.
Sanford, Gerald P., Fuller's Earth of Vrongoch, 160.
Scandinavian Boulders at Cromer, 85.
——— Rocks in English Boulder-clay, 140.
Scientific Papers, Titles of Separate Copies of, 140.
Scotland, The Mountains of, 118.
Seeley, H. G., Structure, Organization and Classification of the Fossil Reptilia, 360.
Seismological Society of Japan, 515.
Selenology, 48.
Sheared Limestones from Ilfracombe, 100.
Shell-beds of Moel Tryfaen, 267.
Sherborn and Chapman, on the Ostracoda of the Gault at Folkestone, 345.
Shone, W., Subterranean Erosion, 142; Cause of Crateriform Sand-Dunes and Cwms, 323.
Shrubsole, O. A., on the Plateau-Gravel of Reading, 190.
——— G. W., Obituary of 480.
Sieger, R., The Rise and Fall of Lake Tanganyika, 379.
Simpson, Martin, Obituary of, 144.
Skiddaw Slates, Occurrence of a Trilobite in the, 29.
Sollas, J. W., Origin of Varieties of Igneous Rocks at Barnavave, Carlingford, 551; on the Minute Structure of the Skeleton of *Monograptus priodon*, 551.
Spilites of Jersey, So-called, 59.
Sponge, A New Genus and Species of, from Canada, 56.
St. Bees Sandstone, 87.
Stebbing, Rev. T. R. R., a History of Crustacea, 324.
Steneosaurus Baroni, R. B. Newton, sp. nov., 194.

STI

Stirrup, Mark, The True Horizon of the Mammoth, 107, 334.
Storms. R., on a Cranium of *Cybium Bleekeri*, 326.
Structure and Classification of the Fossil Reptilia, 360.
Submergence of the British Isles, 104, 277.
Subterranean Erosion, 142.

TAPIR, Evolution of the American, 391.
Taunton, J. H., Obituary of, 576.
Teall, J. J. H., A Coast Section at the Lizard, 136; on a Radiolarian Chert from Mullion Island, 137.
Tertiary Flora of Florida, 472.
——— Granite in the Gabbro of the Cuilin Hills, Skye, 135.
Text Book of Comparative Geology, 361.
Thickness, Expansion and Elevation of Marine Deposits, 255.
Titles of Papers read before Section (C), Geology, 469, 548.
Tomes, R. F., Affinities of the Genus *Astrocœnia*, 378; a New Genus of *Madreporaria*, 379.
Traquair, R. H., on a New Palæoniscid Fish, 54; Devonian Fishes of Campbelltown, etc., 145, 262; a Further Description of *Palæospondylus Gunni*, 471.
Trias, On the Reptilia of the British, 555.
Trilobite in the Skiddaw Slates, 29.
True Horizon of the Mammoth, 20, 107, 161, 334, 353.
Transvaal, Geology of the Southern, 521.
Tuscan Archipelago, 272.
Type Fossils in the Woodwardian Museum, 111.

ULLOMA, Preliminary Notices of the Fossil Bones of, 328.
Ulrich, A., Palæozoic Fossils of Bolivia, 367.
——— G. H. F., on a Meteoric Stone from New Zealand, 130.
United States Geological Survey, Publications of, 523.
Ursus ferox, in the Pleistocene of Malta, 67.
Utah, Fossil Ostracoda from Wyoming, etc., 385.

VARIOLITE of the Lleyn and Associated Volcanic Rocks, 86.

ZUR

Volcanoes of Barren Island, 289.
Volcano of Mergellina, 235.
——— of Rhobell Fawr, The Rocks of the, 337.

WALES, The pre-Cambrian Rocks of, 396.
Walford, E. A., on some Bryozoa from the Inferior Oolite of Shipton Gorge, 285; on Cheilostomatous Bryozoa from the Middle Lias, 379.
Water-bearing Capacity of the New Red Sandstone at Nottingham, 553.
Watts, W. W., Note on a Hornblende-Pikrite from Wicklow, 550; Note on the Perlitic Quartz Grains in Rhyolite, 550.
Wealden of Hastings, Dinosaurian Vertebra from the, 84.
Western Australia, 288, 412.
Westwood, Prof. J. O., Obituary of, 143.
Wethered, E., Microscopic Structure of the Wenlock Limestone, 188.
Wilmore, A., The Carbon-crust on Fossil Plants, 576.
Winchell and Schuchert, on Lower Lias Brachiopoda, 421.
Wisconsin, Fluctuations in the level of Ground-water, 568.
Wood, H. R., Study of the Dykes of Hope, Idaho, 379.
Woods, H., Type Fossils in the Woodwardian Museum, 111; Elementary Palæontology, 570.
Woodward, A. S., on the Cranial Osteology of *Lepidotus* and *Dapedius*, 413; on the Dentition of an Extinct species of *Myliobatis*, 414; Cretaceous Pycnodont Fishes, 433, 487.
——— H., on a New British Species of *Cyclus*, 28; on Fossils applied as Charms or Ornaments, 246; The Recent Geological History of Arctic lands, 575.
——— H. B., on a Bed of Oolitic Iron-ore in Raasay, 493.
——— H. P., Report on the Murchison Gold-fields, 288, 412.
Woodwardian Museum Notes, 64, 249.
Wyoming, The Dissected Volcano of Crandall Basin, 559.

ZIRKEL'S Petrography, 565.
Zittel, Karl A. von, The Development of the Mammalia, 401, 455, 501.
Zurich and Wallen, Note on the Lakes of, 222.

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